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16. ABSTRACT

This edition is a five-year strategy document which describes how the EPA research program plans to address major issues. Each chapter relates to the research applicable to a segment of the Agency's regulatory program. Within each chapter, an introduction defines the area of concern, a section on legislated responsibilities indicates the laws which engender the research program and the body discusses major gaps in scientific and technical knowledge and how they are to be filled to assure a cost-effective regulatory program. The chapters also present selected milestones which indicate the timing of important segments of the research program and resource options for conditions of high, moderate and no growth. These growth scenarios are intended to indicate potential program increases in the Agency's research and development.

The chapters in the report are Energy, Hazardous Air Pollutants, Gases and Particles, Oxidants, Mobile Sources, Pesticides, Radiation, Toxic Chemical Testing and Assessment, Hazardous Wastes, Superfund, Drinking Water, Water Quality, Industrial Wastewater, Municipal Wastewater.

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INTRODUCTION

Research Outlook 1982 is the seventh in this series of reports to Congress required by Section 5 of Public Law 94-475, 90 Stat. 2071. It describes in broad strategic terms the direction of EPA's research program over the next half decade.

The primary purpose of EPA's research program is to support environmental program officials by anticipating their data requirements and by initiating, in advance of regulatory decisions, research projects capable of producing the information which the decision-making process will require.

In 1983, EPA plans to invest more than $200-million in environmental research. Approximately 80 percent of this total supports relatively short-term research on problems of immediate concern to the Agency's regulatory process. The remaining 20 percent supports research into more long-term, fundamental or exploratory areas of science.

This edition of the Research Outlook concentrates upon what the EPA research program plans to do to address major issues. As with any long-term strategy document, this report deals in broad areas and presents general research trends. The strategies presented in this report will eventually be translated, via the research planning process, into more than 2,000 different research projects. As such, this report may leave the reader desirous of greater detail or project-level information. Other research summary documents, which focus on a shorter time horizon than the Research Outlook and contain a far greater level of detail, will be available to fill these needs.

Report Organization

Each chapter of Research Outlook 1982 relates to the research applicable to a particular segment of the Agency's regulatory program.. Within each chapter are several major sections. An introduction defines the area of concern. A section on legislated responsibilities indicates the laws which engender the research program. The main body of the chapter addresses our research strategy — discussing the major gaps in necessary scientific and technical knowledge which must be filled to assure a cost-effective regulatory program, and our strategy with regard to filling those gaps. The next section presents selected major milestones which serve to indicate the timing of important segments of the research program. Finally, a section on resource options is included, as required by the law mandating this report, for conditions of high, moderate and no growth. The percentages associated with these growth options are three percent for moderate growth and six percent for high growth. However, no additional resources are needed nor expected with this submission. Rather, these growth scenarios are intended, as required by the law, to indicate potential program increases in the Agency's research and development.

A general introduction to each of the chapters follows:

Chapter one: Energy -- focuses on four major research areas: acid rain, combustion technology, synthetic fuels, and environmental effects of domestic energy development and use.

Chapter two: Hazardous Air Pollutants -- supports research into environmental processes and effects, health effects, monitoring systems, and quality assurance associated with hazardous air pollutants.

Chapter three: Gases and Particles -- investigates health and environmental effects, monitoring systems and quality assurance, and produces scientific assessments.

Chapter four: Oxidants -- determines exposure and effects, develops air quality models, investigates control technologies and provides quality assurance.

Chapter five: Mobile Sources -- investigates actual human exposure to mobile-source pollutants, fuel additives, diesel emissions, and alternative testing schemes.

Chapter six: Pesticides -- conducts human and environmental risk assessments, and provides quality assurance and scientific support to EPA's pesticide regulatory office.

Chapter seven: Radiation -- investigates the effects of a broad range of non-ionizing radiation frequencies, and supports the nuclear testing programs at the Nevada test site.

Chapter eight: Toxic Chemical Testing and Assessment -- investigates health and environmental effects, provides scientific assessments, monitoring, quality assurance, and engineering support.

Chapter nine: Hazardous Wastes -- provides hazardous waste analysis techniques and risk assessments, develops and tests control technologies, and provides improved spills-response capabilities.

Chapter ten: Superfund -- provides EPA and others with the latest information on the discovery, control, monitoring and cleanup of hazardous material spills and uncontrolled waste sites.

Chapter eleven: Drinking Water -- determines the human exposure and effects of contaminants, develops analytical procedures, tests alternative treatment techniques and ways to protect underground drinking-water sources.

Chapter twelve: Water Quality -- provides measurement and quality assurance methods, health and ecological impact assessments, and other analyses necessary to support water quality and ocean disposal program needs.

Chapter thirteen: Industrial Wastewater -- conducts treatability and early-warning studies, investigates least-cost control options and methods to handle complex effluents, helps ensure data quality and reliability and provides technical assistance.

Chapter fourteen: Municipal Wastewater -- develops improved treatment process designs, encourages use of innovative and alternative technologies, provides health effects assessments of alternative technologies and provides technology transfer to states and municipalities.

Research Priorities

It is impossible to project in detail what environmental research will be necessary over the next half decade. The context for this research is much too dynamic to allow any such projection to be of more than a transient relevance. Legislative mandates may be altered, policies will shift, and public concerns evolve. All these will shape the details of our research program. In addition, and most importantly, that program will shape itself as new research information either highlights the need for added investigation or resolves the problem which was being investigated.

Given this context, however, there are some major research needs which can be said, with some certainty, to hold priority. Some of those major high-priority research areas are listed below. For a more detailed discussion of these priority efforts, please refer to the chapters cited at the end of each item.

Acid deposition. We must have better information on the relationships between the sources of acid deposition precursors and their eventual effects on the receptors of that deposition. This is an issue with enormous resource implications for the industrial and commercial sectors. (Energy)

Groundwater pollution. To control the pollution of groundwater from surface sources, it is necessary to be able to monitor underground pollutant plumes and to predict their behavior. We are testing equipment and developing models to do both. (Hazardous Waste, Drinking Water)

Toxics testing. Toxic chemical testing is an expensive and time-consuming process. Research is being performed to develop more accurate and less expensive test methods, to improve existing screening methods and to support permit exemptions in the Premanufacture Notification process. Such activities will reduce the burden of testing on industry while providing adequate environmental protection. (Toxic Chemical Testing and Assessment)

Measuring toxicity. Determining the toxicity of a complex mixture of wastewaters as a whole would be a far less expensive process than identifying each of the components of the wastewater and attempting to determine their combined effect. We are developing bioassay techniques which should improve our ability to determine the human health implications of wastewater discharge. (Industrial Wastewater)

Determine exposure. In order to more precisely determine the effectiveness of various pollution control strategies, we need to know exactly how much air pollution people inhale. We will be testing personal monitors which measure CO to develop accurate exposure data. (Mobile Sources)

Predictive modeling. In order to provide the necessary tools to state and local decisionmakers responsible for controlling air pollution, we will be refining air pollution models to better explain the relationship between specific sources and ambient air quality, and to better predict the behavior of air pollutants under certain meteorologic and topographic conditions. (Gases and Particles, Oxidants)

Biological pesticides. There is an increasing growth in the development of biological pesticides. EPA is performing research for use in evaluating the possible human health risks of such agents. (Pesticides)

Behavioral effects. Changes in behavior can indicate serious neurological effects at levels far below those required to produce a physical response. We are testing for behavioral effects, in mammals, caused by several potential pollutants. (Several chapters)

In addition to these specific high-priority research areas, other types of activities have a high priority regardless of the chapter in which they are discussed. These priority areas are:

Risk assessment. We are making a major effort to develop more efficient ways of getting technical information into the decision-making process. Various types of risk assessments will serve this purpose.

Regulatory support. The expertise, facilities and information which is developed by EPA's research office is intended to serve the scientific and technical information needs of the regulatory program offices. This will continue to be our highest priority.

Interagency Coordination

There are more than a dozen federal agencies and departments whose responsibilities include some aspects of environmental research and development. [illegible] order to make the best use of available resources and to help assure that there is no unnecessary duplication of effort, an extensive network of interagency contacts, both formal and informal, has been established. The following is a discussion of but a few of the major interagency contacts and agreements.

Interagency Committee for Stratospheric Ozone Protection (ICSOP) was established under the Clean Air Act and consists of 12 federal agencies. The committee is chaired by the EPA's Assistant Administrator for Research and Development, and is divided into subcommittees for atmospheric sciences, health effects and biological and ecological effects. Through this mechanism, the member agencies coordinate their research and monitoring pertaining to stratospheric ozone and ultraviolet radiation.

The National Center for Toxicological Research (NCTR) is supported jointly by EPA and the Food and Drug Administration (FDA). The Jefferson, Arkansas Facility conducts long-term toxicologic studies. Also with FDA, a joint neurotoxicology research program is making significant contributions toward advancing this key new research area.

The Interagency Task Force on Acid Precipitation was established in response to Title VII of the Energy Security Act of 1980. This task force prepared a joint research plan for all participating agencies. EPA co-chairs the task force and has the lead agency research role in three areas: aquatic effects, control technology, and assessment and policy.

The Task Force on Environmental Cancer and Heart and Lung Disease is chaired by EPA and consists of scientists from the National Cancer Institute, the National Heart, Lung and Blood Institute, National Institute for Occupational Safety and Health, National Institute of Environmental Health Sciences, National Center for Health Statistics, Center for Disease Control and FDA. This task force recommends and coordinates federal research programs aimed at reducing or preventing disease caused by environmental factors.

The Committee on Ocean Pollution Research, Development and Monitoring is responsible for developing a research plan and for disseminating information. EPA acts as vice-chairman of this multi-agency group.

In addition, we are coordinating our recombinant DNA work with five other agencies including the National Institutes of Health and the Department of Agriculture. EPA chairs a committee with the Department of the Army to coordinate hazardous waste research of mutual interest. EPA is conducting research for the National Cancer Institute to develop indicator, screening and modeling capabilities for carcinogens, teratogens and mutagens in aquatic systems.

Above are but a few of the formal interagency contacts between EPA's researchers and those of other agencies. We have discovered that the more substantive these contacts, and the more compatible the data on research projects, the more effectively we use our research resources.

ENERGY

INTRODUCTION

The goal of EPA's energy research program is to ensure, in conjunction with industry and other public sectors, that the nation's energy production and use practices proceed in an environmentally acceptable manner. To help achieve this objective, EPA will continue to coordinate its research efforts with other agencies and laboratories conducting energy-related research.

There are five major sub-programs within the energy research program: acid deposition, combustion technology, synthetic fuels, environmental effects and long-term research. The research objectives in each of these areas are described below.

The objective of the acid deposition sub-program is to assess the magnitude, extent and severity of acid deposition effects, the sources of these effects and measures to mitigate them. Acid deposition is a major concern in the Energy Security Act of 1980 and the U.S./Canadian Memorandum of Intent on Transboundary Air Pollution. Research focuses on the emission of acid deposition precursors; their atmospheric transport, transformation and deposition; the evaluation of health, environmental and economic effects and on the assessment of mitigative measures and policy needs.

The combustion technology sub-program supports both technology development and assessment. Several technologies are being investigated to control nitrogen oxides (NO_x), sulfur oxides (SO_x) and particulate emissions. In addition to being suspected as a major contributor to acid deposition, NO_x emissions are the only class of major air pollutants to have apparently increased over the past decade. Low-NO_x combustion technologies are being tested for burning both coal and heavy oil. These technologies show promise for energy-efficient, cost-effective control of NO_x emissions. Additional technologies to control SO_x and particulates are being investigated. These include improved flue gas desulfurization, electrostatic fabric filters, electrostatic precipitators and fabric filters. Finally, an integrated assessment program provides analytic support to the Agency to evaluate alternative energy and environmental management options.

EPA's synthetic fuels research includes health and environmental risk assessments, control technology assessments and cost studies. The goal of the risk assessment program is to give the states and industry usable information on the production processes and waste streams of environmental concern. The control technology assessment and cost studies program evaluates existing control technologies. The objective of these analyses is to provide accurate information to support industrial and regulatory decision making and to provide technical information to environmental officials.

Research into the environmental effects of energy systems has two major components -- cold-climate studies and pollutant transport modeling. The cold-climate research sub-program provides information on specific aspects of energy-related development in climates such as Alaska. Of specific concern are the effects of carbon monoxide (CO) accumulation and of large-scale oil, gas and coal development. The pollutant transport modeling sub-program focuses on developing models for use in regulatory decision making. One of these efforts will modify existing pollutant transport models to take into account the impacts of complex terrain (ridges, hills, etc.) such as is found in western U.S. energy development areas. Another effort will seek to determine the extent to which pollutant movement can be traced for great distances from the source.

Energy program long-term research seeks a better understanding of processes involved in controlling pollutants from synthetic fuels and combustion processes.

LEGISLATED RESPONSIBILITIES

EPA's energy research work directly supports the program offices in their regulatory activities required under such legislation as the Clean Air Act, the Clean Water Act, and the Marine Protection, Research and Sanctuaries Act. In addition, under the Energy Security Act of 1980 (Title VII) the National Acid Precipitation Assessment Program was established. The Act provides for the establishment of an Interagency Task Force on Acid Precipitation. This task force is charged with providing an understanding of the transport and fate of acid deposition, precursors, determining the causes and sources of acid deposition, evaluating the cost-effectiveness of mitigative techniques, and assessing the environmental and health effects of acid deposition. In addition to acting as co-chairman of the interagency task force, EPA has the lead agency research role in the aquatic effects, control technology, and assessment and policy areas.

RESEARCH STRATEGY

The energy research and development program sponsors research that provides a basis for conducting scientifically defensible exposure and risk assessments. Research to improve the state-of-the-art of control technologies is undertaken to reduce control costs and improve efficiency. The program is structured as five major sub-programs: acid desposition (sources, atmospheric processes, deposition monitoring, health and environmental effects, and assessments and policy analysis); conventional combustion technologies (NO_x, SO_x particle control, assessment); environmental effects (cold climate, complex terrain models and atmospheric tracers); synthetic fuels (control technologies and assessment) and long-range studies.

Acid Deposition

In response to the impetus provided under Title VII of the Energy Security Act of 1980, the acid deposition research program is undergoing a significant evolution. For example, the recently formed Interagency Task Force on Acid Precipitation identified high-priority research needs in those areas for which EPA has lead research responsibility. In response to these recommendations, research into the aquatic effects of acid deposition has been augmented, with new work initiated to investigate fish resource loss, aquatic assessment models, and chemical export from terrestrial to aquatic systems. In addition, emphasis is being shifted away from man-made source studies and into assessments of mitigative measures, and additional priority has been given to developing criteria by which to judge the sensitivity of soils to acid precipitation.

EPA's acid deposition research addresses five major areas: emissions, atmospheric processes, monitoring, effects and assessment, as described in the following.

Emissions. The major precursors of acid deposition are sulfur and nitrogen oxides. These originate from both natural and man-made sources, but within the continental U.S., man-made sources are dominant. The National Plan requires the development of a comprehensive data base for existing sources as well as improved capabilities for projecting future emissions from major sectors. Many sources of data are available on current emissions of sulfur and nitrogen oxides. Research is focused on consolidating and reconciling these data to produce a comprehensive data base with the best available information on the magnitude and geographic distribution of man-made emissions. In addition to sulfur and nitrogen oxides, data will be included from all economic sectors on sulfates, hydrochloric acid, and potential neutralizing species.

Research to improve projection capabilities emphasizes the electric utility industry. An advanced electric utility simulation model is currently under development. When completed, this improved model will allow the analysis of the relationships among acid deposition air quality measures, and financial and tax regulations affecting the industry.

Atmospheric processes. Several regional-scale models exist or are under development to project long-range transport and pollutant scavenging processes, cloud physics, transformation reactions and wet deposition. The models focus largely on sulfur oxides, however, and efforts are under way to address nitrogen oxides and related components (ammonia, acetyl nitrates). A major weakness of current models is that dry deposition processes have not been considered. Such processes may be as important as wet deposition in delivering air pollutants to the earth's surface, but adequate measurement methods remain to be developed. Model components will be developed to reflect the amount and types of dry deposition.

The EPA's Environmental Sciences Research Laboratory (ESRL) has the lead role in the management of EPA's regional-scale acid deposition model research, of which the Department of Energy's (DOE) National Laboratories have a major portion of the activity. EPA is working on a coordinated strategy with other federal agencies for the development and evaluation of these refined acid deposition models. This strategy will incorporate the roles of DOE, the DOE National Laboratories, the National Oceanic and Atmospheric Administration, and other federal agencies to help assure that the objectives of the National Acid Precipitation Assessment Plan are met.

EPA-developed and funded regional acid deposition models have been used to study transboundary (U.S./Canada) air pollution transport and deposition as well as the impacts of the conversion of power plants from oil to coal.

Deposition monitoring. Once in the atmosphere, sulfur and nitrogen oxides undergo complex chemical and physical transformations. The products, which are often acidic, may be deposited far from the sources of the precursors. Monitoring sites to collect samples of deposited materials have operated only sporadically until the last three years. Thus, there is considerable uncertainty about the composition and trends of atmospheric deposition in the United States. To help resolve some of these uncertainties, a national data base for the chemistry of precipitation samples has been established by EPA at Research Triangle Park, NC, to make data readily available for all. In addition, a multi-agency-supported National Trends Monitoring Network is in operation.

One high-priority problem is the lack of monitoring techniques for evaluating dry deposition. Efforts are under way to develop and validate such techniques, and a user's guide is scheduled for production by 1984. Throughout this period, efforts will continue to build the National Trends Network data base, assure data quality and improve field site measurement activities.

Effects. The acid deposition effects research program addresses effects on aquatic systems including drinking water, crops, soils, forests and materials. Several of the key unanswered questions, and EPA's research response, are presented below.

First, how does acid deposition affect the quality of drinking water supplies? Research will determine the extent to which acid deposition mobilizes potentially toxic metals from soils and metallic water-delivery systems. These data, including past records of drinking water systems in New York and New England, will permit an accurate health assessment to be made. This assessment, to be completed in 1984, will involve analysis of metals in acidified drinking water supplies and ground water resources, including individual wells and community systems.

Second, what is the extent of acid deposition damage to fisheries? Field surveys are being conducted to determine the sensitivity of lakes and streams to acid precipitation and the extent to which these waters are being acidified. Research will determine the location of aquatic resources impacted by acid deposition and will evaluate the extent of the problem. A clearer picture of the overall impacts of acid deposition will be available when these data are integrated with the results of research on the possible extent and rates of future acidification and the impacts of acidified waters on fish and other parts of aquatic ecosystems. Such data on acidification and fish loss will be used to provide an initial assessment of the regional extent of the impact of acid precipitation on aquatic ecosystems. This information will be made available in 1984.

Third, are there any cost-effective techniques available to mitigate the impacts of acid deposition? Research will seek short-term ways to protect and/or restore aquatic ecosystems. Such mitigative techniques as the introduction of lime and binding agents for toxic metals will be developed and tested. The cost-effectiveness of such techniques will be assessed. Field studies will determine the utility of management procedures in restoring impacted ecosystems to productive status.

Fourth, what are the effects of acid deposition on economic goods such as crops, forests and construction materials? Research will focus on soil chemistry, the mobilization of chemicals, microbial processes and ways to predict nutrient cycling for a few soil/forest types. Some effort will continue in studying the effects of acid precipitation, alone and with other pollutants, on crop yield. In addition, construction materials such as metals, stone and masonry are being exposed to acid deposition and their responses catalogued. These data will significantly improve economic analyses beginning in 1984.

Assessment and policy analysis. This program is reponsible for tying together, through the integrated assessment process, results of a wide range of scientific research into a framework to support policy decisions. By 1984, a preliminary integrated assessment will be completed. This effort seeks to capture causal relationships in the chain of events which produce acid deposition, and to identify uncertainties in current knowledge at each link. The methodology can then be applied in evaluating the overall costs and effectiveness of alternative control and mitigation strategies. The methodology will be tested by application to a comparison of the costs and effectiveness of SO_2 versus NO_x emissions control strategies. This effort will examine the extent to which current scientific knowledge will support conclusions as to the relative cost-effectiveness of these strategies, describe the range of uncertainty around these conclusions, and identify the information needed to reduce these uncertainties. An acid deposition critical assessment document will be produced, providing a review and analysis of the current scientific understanding of all aspects of the acid deposition phenomenon.

The program will also conduct analyses of the sensitivity of policy-related conclusions to various key gaps in existing knowledge as a guide for future research priorities. Economic and performance information for a range of control or mitigation options will be assembled and evaluated for use in integrated assessments. By 1984, analysis of control strategies for the electric utility industry will be possible through an advanced utility simulation model. Less detailed information will be available on control options for other source sectors and aquatic mitigation measures. Several short-term analyses of important acid deposition issues, such as the relative importance of local versus long-range sources, and expected retirement age for major emitting facilities, will be completed.

Combustion Technology

While data on the availability of combustion technologies are well established, optimized design for minimum pollution and maximum energy efficiency is a relatively new field. Significant opportunities appear to be available to allow low-NO_x combustion of heavy liquid fuels and coal, and simultaneous control of SO_x and NO_x. Several of the most promising technologies or techniques are being investigated under the combustion technology sub-program.

In several oil field regions in California and Texas, oil recovery may be limited by emissions limitations. Steam is used to free and recover intransigent oil deposits. To be economical, this steam must be generated by burning low-grade, high-nitrogen-content heavy liquid fuels. A new burner will be field evaluated in 1983. If this burner design proves to be cost-effective in reducing NO_x emissions, it will be applicable to conventional oil-fired industrial boilers as well. As such, the technology would be valuable when the new source performance standards for industrial boilers are revised.

Combustion modification (low excess air, flue gas recirculation, staged combustion) offers the possibility of reduced NO_x emissions and increased energy efficiency for coal-fired boilers. Data from a full-scale test of a spreader-stoker boiler will be used to provide input to guideline documents for boiler modification. Studies of combustion modification costs and emissions for one mass-fed stoker will be available in 1985. This data will be compiled into a technology assessment report.

To improve control of NO_x emissions, it is essential to understand how NO_x is created during combustion. Various types of coal have different properties that influence their emissions. Studies will be conducted under staged and unstaged combustion conditions with various coals, and the resulting NO_x emissions will be characterized.

Emissions of NO_x and SO_x are suspected to account for the vast majority of the precursors of acid precipitation. Two of the most promising control techniques for NO_x and SO_x are being further developed. These are low-NO_x combustion (to reduce NO_x emissions) and the limestone injected multistage burner (LIMB) (to control both NO_x and SO_x simultaneously). Both of these technologies are being improved -- and their cost-effectiveness assessed -- as part of this sub-program. Data on emissions, reliability, boiler efficiency, and fouling will be developed for several applications at pilot demonstration scale.

The LIMB technology combusts a mixture of pulverized coal and limestone. Initial results indicate that this technique may reduce both NO_x and SO_x emissions at substantially less cost than wet scrubbing for SO_x alone. The results of tests, assessing a number of variations in coal and burner type and operating conditions will yield key information for determining both the practicality and economics of such technology.

Another major effort within the combustion technology sub-program is the assessment and development of SO_x and particulate control technology. This research program provides technical assistance to states, EPA and the private sector on control technology innovations, performance, costs and reliability. Such information is central to revising State Implementation Plans and setting new source performance standards.

Continuing efforts will focus on the potential application of spray dryer SO_x control technologies as an adjunct to the LIMB processes. Data will be acquired to determine the reliability of spray-dryer processes, and tests are planned to evaluate the ability of a full-scale sprayer-dryer to comply with the SO_x emissions regulations for utility boilers.

Particulate control research will focus on alternative baghouse fabrics, precharging of electrostatic precipitators, and electrical enhancement of fabric filters, in general, in both the pulsed jet and reverse air modes. Research on innovative filters for combined SO_x/particle removal will be initiated. Large-scale conventionally-designed baghouses will be monitored to evaluate the capability of this technology for meeting utility and industrial boiler new source performance standards. A potential simplification of the dry SO_x control technology at pilot scale will be assessed, and research on flue gas conditioning as a means of improving particulate control during delayed compliance periods will be completed.

Performance of particulate control equipment declines with use due to aging of critical components, poor maintenance practices and/or improper operations. Evaluations have verified that these factors account for the major causes of less-than-design performance. Operational and maintenance (O&M) problems can generally be corrected at low cost when the problems are understood. A forthcoming research report will provide information on O&M practices to help owners and operators of particulate control equipment to obtain design performance.

Integrated assessment activities focus on two areas -- the development and/or improvement of models to support regulatory analysis and the assessment of alternative approaches to environmental regulation. Major model development activities will concentrate on an interactive coal and electric utilities data system to give EPA users information on coal mining and transportation and electric utility operations. The easy accessibility of such data can significantly speed regulatory and permitting processes. In developing alternative approaches to environmental regulation, emphasis will be on shifting responsibilities to states and on streamlining regulatory procedures. This research supports EPA's program offices (OANR, OPA). In conducting this research, we rely upon data gathered by the DOE and other sources wherever possible.

Synthetic Fuels

Synthetic fuels are liquids and gases produced from coal and oil shale. A significant amount of environmental research has already been done in the synfuels area, and it is expected that future environmental research will keep pace with the slowed synfuels commercialization process. As synthetic fuel plants are developed, accurate information on associated pollutants and control techniques will assist both the industry and environmental regulators. Such information will be of use to industry in choosing the necessary and optimum environmental controls and to environmental regulators in developing environmental impact statements and new source performance standards for air and water. It will also be useful in identifying the controls necessary for the prevention of significant air quality deterioration and in controlling water pollution and solid waste.

The emphasis in this sub-program will be twofold. First, it will provide the information necessary to determine the health and environmental implications of large-scale synfuels plants. Second, it will provide technical information and support regarding cost-effective synfuels pollutant control technology to environmental management officials. The research goals will be to conduct source testing and monitoring, to evaluate synfuels control technology options, to field test water pollution control technology at an oil-shale site and to conduct source testing at an H-coal pilot plant. Research to date has been conducted at laboratory, bench and pilot domestic facilities and some large-scale commercial sites. Major work has been conducted at the coal gasification facility at Kosovo (Yugoslavia) and Tennessee Valley Authority facilities (Muscle Shoals).

The integrated Health and Environmental Risk Analysis Program (HERAP) attempts to predict health and environmental risks associated with the emission of specific compounds from synfuel plants.

Efforts to provide monitoring guidance for synfuels documents will be concluded by 1983, and risk-benefit assessments will be limited to utilizing existing data and addressing major research endpoints. These risk-assessment efforts will build upon expertise within the federal agencies, the national energy laboratories and industry to develop multimedia analyses for selected energy development projects. Data bases for pollutant lifetimes, transformation reactions, deposition, and bioaccumulation will be integrated to assess atmospheric and groundwater pathways. Ultimately, these efforts will be used to determine those source-receptor relationships which are key to clarifying the health, economic and social constraints on synthetic fuels development.

Environmental Effects

There are three major research activities within the environmental effects sub-program: air quality modeling (tracers), complex terrain modeling and cold-climate studies.

Air quality models are essential tools for regional, state and local officials who must develop plans for meeting air quality standards. One such model is the complex terrain model currently under development as part of this program. Complex terrain models are especially important in the western states where new energy developments will emit air pollutants whose trajectories are complicated by mountains, ridges, valleys, etc. Data from field studies will be used to improve available models and assessments will be made to determine the transferability of such models to different types of complex terrains.

Results of these efforts will be available in 1984, and a complex terrain model user's guide is planned for 1985. Information on dispersion coefficients in certain complex terrains will be developed by field study, and results will be available in 1984.

Current air quality modeling research is making major contributions to understanding the formation and movement of large-scale air masses. A multi-state field study was conducted in 1980 to establish the first available data base on this problem. A second major field study is planned for 1984. Current research is investigating less expensive and more effective means to track air parcels.

Atmospheric tracers can be released in small amounts at selected sites, and later accurately measured as far as 1,000 km away. Such trace data could be used to verify air quality model calculations. Field tests will be conducted in 1982 and a full-scale test of these tracers is planned for 1984. The resultant data will be useful in testing long-range transport models for acid deposition. In addition, assessments will be made of climatic impacts (radiative balance, atmospheric stability) of polluted air masses.

Energy development in cold climates such as Alaska pose a unique and challenging set of environmental constraints. One major issue is the concentration of carbon monoxide (CO) in metropolitan areas. Ongoing automobile emission studies will be completed in 1983. Meteorological and emission data will be used to develop an early warning system for high CO levels, and mitigative techniques such as an inspection/maintenance program, retrofit devices and alternative fuels will be evaluated. Research into the environmental impacts of oil and gas development will include a retrospective evaluation of erosion and sedimentation and an evaluation of the effectiveness of various mitigative measures.

Long-term Research

Long-term exploratory energy research will concentrate on a number of basic energy-related processes including the identification and control of pollutants from synthetic fuels processes the study of the basic parameters of fossil fuel combustion and the formation of polycyclic or carcinogenic material. Other activities may investigate control options for synthetic fuels facilities, such as novel H_2S control systems. In support of the cold-climate research subprogram, research will be conducted to develop improved soil reclamation techniques for permafrost and tundra ecosystems. Additional work will be conducted on the development of models to handle wind fields in complex terrains.

MAJOR MILESTONES

Acid Deposition

- Complete the acid deposition critical assessment document - 3/1983
- Compile and evaluate mitigative measures - 9/1983
- Determine location of impacted lakes and streams - 10/1983
- Determine corrosion effects, drinking water impacts - 10/1983
- Develop and test dry deposition monitoring method - 1/1984
- Complete SO_x/NO_x emissions inventory and advanced utility assessment model - 1/1985
- Evaluate effects on crops, fish, forest - 10/1985

Combustion Technology

- Provide interim assessment of low-NO_x burners and combined SO_x/NO_x control based upon limited scale tests - 9/1983
- Complete pilot evaluation of tri-electrode electrostatic precipitator - 10/1983
- O&M procedures for ESP - 10/1983
- Report on heavy oil low-NO_x burner - 11/1983
- FGD state of the art - 12/1983
- Complete field test for spray dry SO_x FGD - 9/1984
- Report on combustion modification as applied to low-NO_x coal-fired stoker boilers - 10/1985

Synthetic Fuels

- Complete pollution control technical manuals for three oil shale and four coal synfuels processes - 9/1982
- Complete ambient and source monitoring reference manual - 12/1982
- Assess performance of control technology at one surface oil shale retort and source test H-coal pilot plant - 3/1983
- Define pollutants for which data is needed and gaps in models, methods and relationships - 3/1983
- Complete first health and environmental risk analyses for one liquefaction and one oil shale technology - 9/1983

Environmental Effects

- Develop preliminary 'early warning' system for high CO concentrations - 9/1983
- Report on regulatory and siting use of complex terrain dispersion model - 8/1984
- Test and prove long-range air pollutant transport tracer techniques - 12/1984

Other

- Provide EPA with interactive coal utility data system and residual accounting model - 9/1983

RESOURCE OPTIONS

1982 Current Estimate 52.5

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	34.5	34.5	34.5	34.5
MODERATE	34.5	35.5	36.6	37.7
HIGH	34.5	36.6	38.8	41.1

Figures are in millions of dollars.

No growth. The primary emphasis will be on assessing the impacts of acid deposition and synthetic fuels, evaluating conventional combustion control technologies, and developing and refining complex terrain models.

Moderate growth. The acid deposition and synthetic fuels research programs will receive the primary emphasis. In the acid deposition area, research will continue to focus on the emission of acid deposition precursors; their atmospheric transport and deposition; the potential health and environmental effects; the damage to materials; and potential mitigative measures. In the synthetic fuels area, research will continue to focus on developing integrated health and environmental risk assessments; evaluating alternative control technologies; and providing technical support to the regions and states. The research program will be adjusted to keep pace with commercialization schedule as it changes. To respond to the needs of the regulatory program offices, emphasis will also be placed on evaluating the reliability, performance and cost-effectiveness of conventional combustion control technologies, and on refining complex terrain models.

High growth. Research on the causes, effects and methods of mitigating acid deposition will be accelerated with greater emphasis placed on the relationship of sources of acid deposition precursors to receptors. In the synthetic fuels area, depending upon the commercialization efforts by industry, emphasis may be increased on assessing the health effects of synfuel products and by-products, and on developing integrated health and environmental risk assessments. In addition, research to develop the necessary performance, reliability and cost data for conventional combustion control technologies will be augmented, as will research to develop additional models for different types of complex terrain.

HAZARDOUS AIR POLLUTANTS

INTRODUCTION

The Hazardous Air Pollutants (HAP) Research Program provides scientific support for identifying and evaluating airborne substances which adversely affect human health. The goals of this program are to characterize and assess conditions as they now exist and to gather information about new and potential pollutants, their interaction with the environment and their impact on human health. This type of information is key to determining the degree to which the initiation or continuation of control measures is necessary.

LEGISLATED RESPONSIBILITIES

Section 112 of the Clean Air Act provides the basis for the Environmental Protection Agency's regulatory efforts to control the adverse effects of hazardous air pollutants. Under this health-based section, seven air pollutants -- mercury, beryllium, asbestos, vinyl chloride, benzene, radionuclides and inorganic arsenic -- have been listed as hazardous. Regulations have been promulgated for the first four of these. They are proposed for benzene.

RESEARCH STRATEGY

The hazardous air pollutant research program interfaces with the various stages of the regulatory process, and the research focuses on a list of potentially hazardous air pollutants which was developed by the EPA Office of Air Quality Planning and Standards. In the first stage, new, potentially hazardous air pollutants are identified through literature searches of scientific reports. Candidate substances are then screened to determine the potential for public exposure through ambient air emissions. This is accomplished by collecting and assessing information on intentional and inadvertent production, uses, volatility and other physical and chemical properties. Based upon the data collected in this process, a list of substances which require further assessment is developed. The Office of Health and Environmental Assessment then evaluates available health effects data and estimates the potential for human risk. These risk assessments are then combined with preliminary exposure analyses to provide quantitative estimates of degree of risk and of disease incidence in the population.

Research is conducted as necessary to document health risks, determine environmental impacts, and develop and evaluate control options and monitoring capabilities for specific pollutants. This information is central to determining whether a specific pollutant or source category requires control or whether existing control requirements should be revised.

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The research to support this process is divided into five major components: (1) scientific assessments (2) environmental processes and effects (3) monitoring systems and quality assurance (4) health effects and (5) exploratory research.

Scientific Assessments

Agency efforts to prevent harmful exposure to environmental agents require accurate assessments of the types of adverse health effects to be expected, the amount of human exposure likely to occur under actual environmental conditions, and the reduction in hazard likely to occur if a particular regulation is implemented. These assessments must withstand rigorous scientific peer review and be structured such that a defensible regulatory decision can be formulated.

Scientific assessments are analyses of human health and animal research, monitoring surveys, and data on the environmental fate and transport of pollutants. The key elements of the analysis are:

- A determination of the likelihood that the chemical in question causes cancer, mutations, birth defects, or neurological, pulmonary or other toxic effects,

- A determination of the dose-response relationship for each suspected or demonstrable effect, and

- A set of recommendations regarding the most likely exposure levels which would result in a toxic effect.

Environmental Processes and Effects

The primary purpose of this program is to develop models to predict the movement, transformation and fate of potentially hazardous air pollutants emitted into the air. Chamber and field studies are necessary to design and update models. Analytical chemistry support is an integral part of laboratory and field studies using state-of-the-art methods.

Monitoring Systems and Quality Assurance

This area of activity combines short-term, state-of-the-art application of technology in support of regulatory requirements and applied research to advance the state-of-the-art for environmental monitoring. Specific areas of research include the development of low-cost, rapid analytical methods such as continuous monitors for regulatory needs in ambient and source categories. The trend will be toward methods development and toxicity testing aimed at specific chemicals, or elements, rather than at source-related complex mixtures. Compounds selected for study include asbestos, halocarbons, metals and volatile organic compounds in the air or attached to particulate matter in the air.

This program will continue to provide quality assurance procedures for current and new methods and will provide analytical support for health-related tests. This will include the development of testing procedures, the preparation of standard reference materials, the measurement of the stability of reference materials, interlaboratory testing, and laboratory audits. New and improved procedures will be developed for trend monitoring and surveillance and analysis. Systems development will be conducted as required, utilizing new analytical devices and techniques such as portable mass spectrometer systems, laser desorption techniques, micro-liquid chromatography and new sorbents for collecting hazardous air pollutants. Research will be conducted in the area of exposure measurement to be applied to needs of health assessment documents and regulation revision.

Health Effects Research

The two major objectives of the health effects research on hazardous air pollutants are: (1) the screening and identification of biologically active compounds so that appropriate candidate substances are prioritized for further analyses, and (2) the conduct of detailed assessments of selected substances in support of regulatory decisions. These operations are conducted in each of four areas of health effects -- neurological, developmental, mutagenic and metabolic.

The effects of hazardous air pollutants on the nervous system and associated behavioral effects will be studied. In this relatively new area, test methods will be developed, validated and streamlined. Studies will be conducted and effects measured on a broad array of tests. These include tests of sensory and cognitive function, electrophysiological assessment of brain activity and, in animals, neurochemical, metabolic and anatomical measures. The battery of new and established bioassays is currently being used to study high-priority chemicals.

The developing organism is often highly susceptible to toxic effects at certain stages of life. Potentially hazardous air pollutant substances will be administered to susceptible age groups of animals and their effects studied. In addition, studies in adult male rats will determine reproductive toxicity through exposure to suspect substances and subsequent measurement of sperm count, serum hormone levels and other indices.

With regard to potential cancer-causing agents in air, several bioassays will be used to screen components of ambient air and to study compounds in the laboratory. Microbiological techniques will be used to fractionate air samples and identify mutagens. Animal and human tissues will be cultured in order to examine gene mutation, chromosomal effects, and also metabolic activity in human lung cells.

Metabolism of materials foreign to the body is affected by some metals and organic compounds in such a way as to either activate another chemical to greater toxicity (e.g., paraquat), or detoxify a chemical (e.g., ethylene dibromide). Metals, complex mixtures and suspected hazardous air pollutants will be tested for effects on the susceptibility of mammals to infectious respiratory disease. Mice will be exposed to inhaled hydrocarbons, cadmium, vanadium, nickel, toluene and other substances and tested using a pulmonary infectivity model and metabolic tests.

Exploratory Research

To achieve a reasonable balance between the immediate regulatory needs and the general advancement of science through longer-term activities, some resources are allocated to long-term exploratory research. In this context, research on the development and testing of exposure methodology for hazardous air pollutants will be conducted.

MAJOR MILESTONES

The following are a few major accomplishments planned for the hazardous air pollutant research program:

Scientific Assessment

- Three comprehensive health hazard assessments will be completed, and four to five new assessments will be initiated for the Office of Air Quality Planning and Standards (OAQPS) to define the nature of health hazards associated with pollutant-specific emission situations. 4/1983

- Identify and prioritize candidate hazardous substances. Provide ten screening health assessments which will define the range of chronic health potentials - 10/1983

- Assessments will be produced for use by OAQPS to define the nature of health hazards for candidate pollutants for listing under Section 112 - annually through 1986

Environmental Processes and Effects

- Determine the rates of photolytic decomposition in the troposphere and the decomposition products for type I HAPs that are vulnerable to photolysis - 6/1984
- Final report on rates of dry deposition of selected HAPs from air to surfaces near to sources - 7/1984
- The atmospheric chemistry of approximately 20 Type I HAPs will be fully characterized to model the buildup of hazardous air pollutants in ambient air - 8/1984
- Screening of high-volume emissions for potentially hazardous transformation products as predicted by structure-activity relationships - 8/1985

Monitoring Systems and Quality Assurance

- Develop and validate methodology for use in gathering background data to determine the need for, or compliance with, emission standards. Methods for trichloroethylene and specific chemicals from coke-oven emissions (i.e. PNAs, BaP) will be developed - 9/1983
- Two state-of-the-art source emission continuous monitors (SECM) will be evaluated under field conditions. These studies will become the basis for establishing recommended performance specifications - 9/1983
- Develop improved source sampling methods for volatile compounds -12/1983
- Establish ambient air monitoring centers for hazardous non-criteria air pollutants - 6/1984

Health Effects Research

- Neurological and behavioral dose-response relationships will be evaluated for toluene, as a surrogate for other chemicals, in humans and animals and for alkyltins in laboratory animals - 4/1983
- Evaluate respiratory and immune dysfunction in laboratory animals stimulated by exposures to four hazardous air pollutants - 4/1984
- Report on the evaluation of short-term and long-term dose-response relationships of reproductive effects of selected industrial effluents - 10/1985

- Develop and validate a test system to measure reproductive and teratogenic effects of hazardous air pollutants using classic and innovative methods - 10/1985
- Identify mutagens in complex air emissions and compare their relative toxicity using gene mutation and related bioassays - 4/1986

RESOURCE OPTIONS

1982 Current Estimate 9.4

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	8.0	8.0	8.0	8.0
MODERATE	8.0	8.2	8.5	8.7
HIGH	8.0	8.5	9.0	9.5

Figures are in millions of dollars.

No growth: To respond to priority assessment needs, emphasis will be placed on the development of new short-term bioassay tests for screening potential hazardous air pollutants. Also, emphasis will be placed on research to develop methods to permit improved characterization of ambient air for chemical composition, frequency of occurrence, and the composition of hazardous air pollutants.

Moderate growth: The program will continue to emphasize the analysis and screening of hazardous air pollutants and the determination of the adverse health effects of those contaminants. Emphasis will be placed on the development of biological and chemical methodology to fulfill the needs of an expanded ambient urban-air characterization program. Emphasis will also be placed on the development of stationary-source measurement methodology and apportionment modeling to permit identification of pollutant sources as candidates for regulatory action.

High growth: Additional risk assessments will be produced, and improved health effects techniques and monitoring systems will be developed. Research will focus on volatile and semi-volatile organic compounds. Research to develop stationary source measurement methodologies will be expanded as will modeling efforts in this area.

GASES AND PARTICLES

INTRODUCTION

EPA's research program investigating airborne gases and particles addresses three major classes of air pollutants -- sulfur oxides, particles and lead -- and combinations of these substances with other criteria pollutants such as ozone and nitrogen oxides.

The principal sulfur oxides of concern are sulfur dioxide (SO_2) (gas), sulfuric acid and sulfates. For EPA's purposes, particulate matter is broken into three size groupings -- fine (less than 2.5 microns), coarse (greater than 10 microns) and inhalable (less than 10 microns or PM_{10}). The lead particles included in this research program are those commonly found in urban air.

Specifically excluded from this chapter is discussion of diesel-related particles (discussed in the mobile sources chapter), studies associated with acid precipitation (discussed in the chapter on energy) and investigation into those particles which are carcinogenic, mutagenic or otherwise hazardous. The latter particles are discussed in the chapter on hazardous air pollutants.

The three overall goals of this research program are to:

Support standard setting and revision. The law requires that air quality standards be reviewed every five years to determine if, in light of new scientific evidence, the standards should be changed. Improved scientific information is incorporated into ambient air quality criteria documents, the foundation upon which new or revised standards are built. The more precise these documents, the better will be the standards. Criteria documents are among the main products of the gases and particles research program.

Develop enforcement tools. Decision making in environmental regulation requires supportive tools, such as models and monitoring methods, that are convenient, accurate and usable from the regulator's perspective. The better these tools are, the more efficient and cost-effective the regulatory process will be. EPA's gases and particles research program is a main source of improvements in monitoring techniques and models.

Provide quality assurance. Literally millions of environmental measurements are made in this country each year, many using highly sensitive equipment and/or complex methods. This testing and measurement is at the core of the regulatory process. Unless done correctly, the measurements can be worthless or counterproductive. Much of the responsibility for this process lies with state and local agencies and EPA regional offices. Part of the purpose of the gases and particles research program is to provide those organizations with the guidance necessary to assure quality measurements.

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There are five major activities supported by the gases and particles research program. First, develop and test air quality models, monitoring techniques and supportive atmospheric chemistry as tools for regional, state and local air quality offices. These authorities are required to develop plans that will allow their communities to achieve air quality standards. To assure that they will work, these plans must be tested using sophisticated computerized air quality dispersion models using emissions data, meteorology and air chemistry. While some air quality dispersion models exist and are in use today, the models necessary to estimate concentrations of particles less than 10 microns (PM_{10}), and to determine the effects of rough terrain need to be improved. An additional key project is developing and validating methods for apportionment of particulate mass to specific emission sources.

Second, determine exposure and effects of gases and particles on human health and sensitive ecosystems. Such information is incorporated into criteria documents and used by EPA to determine the adequacy of ambient air quality standards. This program provides technical assistance and benefits assessment to EPA and state regulatory offices and produces the key information to support decisions by EPA regarding future updates and revisions of air quality standards. This program provides much of the health and welfare effects, monitoring, modeling and materials damage information required for the above-mentioned regulatory activities, and includes clinical and animal inhalation toxicological studies on exposure to energy pollutants such as SO_2 and ammonia sulfate.

Third, provide quality assurance support to state and local agencies and regional offices as required to ensure the reliability and accuracy of all data generated and used within this research program area.

Fourth, provide technical information and liaison functions that allow states and regions to obtain, in usable form, the scientific information they need to do their regulatory jobs well.

Fifth, support long-term research into the fundamental processes that determine the generation, effects and control of gases and particles.

LEGISLATED RESPONSIBILITIES

Research in the gases and particles area supports the Clean Air Act as amended in 1977. The major relevant provisions of that Act are those providing for the national ambient air quality standards (NAAQS), development of State Implementation Plans (SIPs), new source performance standards (NSPS), prevention of significant deterioration (PSD), and protection of visibility. Each of these provisions is discussed below.

Air quality standards. The Clean Air Act (Sections 108 and 109) requires the establishment of two types of air quality standards. Primary standards protect human health. Secondary standards protect the public welfare. EPA develops and must review, at least every five years, the technical foundations for the standards which it sets. The documents that set forth the new scientific information used in this review process are called criteria documents -- they establish the scientific criteria upon which standards decisions are based.

To date, NAAQS have been promulgated for seven pollutants including the three which are the focus of this chapter --sulfur oxides (SO_x), particles (as total suspended particulates) and airborne lead. EPA has recently revised the criteria document for SO_x/particulate matter, and is now reviewing the scientific base for revising the standard. The criteria document for airborne lead will be revised early in 1984.

State implementation plans (SIPs). Within nine months after the EPA sets a standard, the states are required to submit plans (SIPs) indicating how they intend to attain primary standards within three to five years and secondary standards within a "reasonable time." A number of air quality areas may require increased controls if they are to meet air quality standards. The types of controls will depend, to a great extent, upon the data available about those controls and upon the accuracy of the air pollutant dispersion models used by the states to analyze their plans.

New source performance standards. The Clean Air Act (Section 111) requires standards to be set for new or modified sources of pollution. These standards may cover both criteria and non-criteria (for which NAAQS standards have not been set) pollutants. Standards for a specific type of pollution source (for example, an industry category such as electric utilities) must reflect the best control technology that has, considering cost, been adequately demonstrated. Developing these standards requires accurate data, including technical and economic data on control technologies. New source standards exist for several industry sources of particulate matter and sulfur oxides (i.e., utility boilers, sulfuric acid plants). In addition, a number of additional new source standards are being prepared.

Prevention of significant deterioration. The Clean Air Act (Section 160-169) also establishes national requirements for prevention of the significant deterioration of air quality. Congress has established maximum allowable increases in concentrations of sulfur oxides and particulate matter for various classes of land areas. This action and other proposed regulatory approaches to maintaining air quality require accurate methods for determining the probable impacts of major new pollution sources. Sophisticated computerized models of atmospheric processes exist and others are being developed and validated. These models will provide decision makers with the information they need to predict the probable impacts on air quality from new emission sources.

Visibility protection. In areas such as national parks where visibility is an important value, the Clean Air Act (Sections 165 and 169A) establishes a national goal of enhancing and preserving good visibility. Initial regulations for visibility protection were promulgated in 1980 for both new and existing pollution sources. These regulations deal with single-source impacts.

RESEARCH STRATEGY

Research in the gases and particles program is designed to meet the information requirements identified in the preceding section on legislated responsibilities. The basic objectives described in the introduction to this chapter guide the development of this research program.

As research goals are translated into research projects, a shift is made from the problem orientation described in the Legislative Responsibilities section, to the discipline orientation that structures the scientific community. The following discussion reflects a transitional stage in that shift. It presents our program as divided into five distinct research areas corresponding, to a greater or lesser degree, with the discipline orientations of the research community. These five areas are as follows:

Environmental processes and effects
Monitoring systems and quality assurance
Health effects
Scientific assessment
Long-term research

Environmental Processes and Effects

Research into the environmental processes and effects related to gases and particles produces information on three major questions facing environmental regulators: What are the ecological effects of these pollutants and what do these effects cost? What types of damage do these pollutants do to construction and other materials and what is that cost? What is the relationship between specific pollution sources and the ambient concentrations of the pollutants they emit? Research strategies to address these three questions are as follows:

The ecological effects of gases and particles will be evaluated to support criteria document revisions and to provide technical assistance to the Agency, and to state and local governments concerning the ecological effects of sulfur dioxide and particulates. This activity will primarily focus on the evaluation of past data sets for integration of exposure data with impacts. Research will focus, through 1986, on the impacts of ozone interactions with sulfur dioxide to field validate the effects of ozone/sulfur dioxide mixtures on major crop species.

Five experimental sites have been established in the Northeast, Southeast, Midwest and West to study the impacts of SO_2, NO_2 and ozone, alone and in combination. These studies will be continued to yield a valid dose-response function for these pollutants for various crops. Results of this work will be used in economic assessment studies of air pollutant effects upon the agricultural economy. Results available in the 1983 to 1985 time frame will document the SO_2 dose-response relationships for various crops.

Efforts to determine actual air quality in rural (agricultural) areas have been limited in the past. Available ambient air quality data and existing air quality models will be adapted to generate an exposure/dose data base for both SO_2 and ozone. Validated air quality models will be completed in 1985-1986 and integration of air quality models with crop-yield data will be initiated in 1983 and be completed in 1986-1987.

The costs of damage done to materials by gases and particulate pollutants may be significant. Acidic deposition, sulfur dioxide, particles, oxidants, and other pollutants accelerate the degradation of both construction and ornamental materials. Masonry, paints, plastics and metals are damaged by these pollutants. The exact dose-response relationship, however, is poorly documented.

The mechanisms for material damage from gaseous sulfur dioxide and acid deposition are closely integrated and must be studied together. Therefore, research into materials damage funded by the energy program's acid deposition sub-program is planned in close coordination with such research conducted under the gases and particles program.

Work will continue to measure accurately the effects of these pollutants upon exposed construction materials, to determine concomitant maintenance costs, and to provide adequate data for the development and validation of an integrated damage model. By 1984, such an integrated damage model will be tested, and the collection of data will begin on the type and quantity of exposed materials nationwide. Model output will be in terms of dollars lost by materials damage from air pollutants on a standard metropolitan statistical area (SMSA) basis. Fewer than 10 damage functions (for zinc, steels, paint and building materials) cover the majority of exposed vulnerable materials. The rates of weathering (corrosion and erosion) and soiling are known to be a function of not only air pollution levels but also of temperature, relative humidity, precipitation and type of material. Data for these parameters will be gradually developed to improve the quality of the eventual model output.

Air quality models are being developed and validated to help trace the relationship beween pollutant source and ambient concentration. Standards require that certain ambient levels of pollutants not be exceeded. To effectively enforce those standards requires knowledge of pollutant dispersion/deposition patterns. There are two types of models which can be used to aid this process. One type projects how pollutants emitted by a specific source or group of sources will disperse to the downwind points which will eventually receive the pollutants. These are called dispersion models. The other type of model takes a mix of pollutants as measured at a particular receptor point and traces the pollutants back to their sources. This is called a receptor model.

Receptor models are expected to be more cost-effective in developing SIPs than dispersion models because the latter require expensive inventories of emissions and their sources. Receptor models are simpler to use, but they do require extensive chemical composition and size distribution data. Using this data, which is obtained through the analysis of collected aerosol particles, receptor models can be used to quantitatively relate or apportion the pollutants to their respective emission sources. The combined use of both of these methods may effectively bridge gaps in the input data for either method. It is expected that the receptor and dispersion methods together will provide the basis for aerosol source apportionment and control strategy development. These same methods can be used for apportioning visibility reduction to specific source types. Source apportionment methods (SAM) will be developed and validated for apportioning particulate mass to specific emission sources. Such methods will be applicable to given particle size ranges.

There exist several analytical methods to characterize the chemical composition of aerosols. When this is done, source and ambient air samples can be compared to establish source/receptor relationships, from which the two major source apportionment methods, chemical element balance (CEB) and target transformation factor analysis (TTFA), can be tested for their ability to resolve sources. A major field study in an urban area is planned to validate receptor models and to compare them with dispersion models. Additional work is planned to develop ways to identify the unique characteristics of pollutants from a particular source. These characteristics are referred to as the source signature.

During 1983, field study data will be used to evaluate the source apportionment methods (CEB and TTFA) under development. Computer codes, documentation and user's guides for the CEB and TTFA methods for interim usage in the 1984 to 1985 time frame will be produced. Further reports will be produced in this period describing the application of CEB and TTFA to aerosols collected in various locations as well as a report describing the accuracy of the TTFA in comparison to mathematical simulation tests and the results of CEB analysis.

How particles travel after they are emitted into the air is important. Equally as important, from the perspective of human health, is the size of the particles.

EPA may revise the particulate National Ambient Air Quality Standard by introducing size- and chemically-speciated standards. Under consideration are standards for inhalable particles (less than 10 microns, or PM_{10}), and fine particles (less than 2.5 microns). Currently available models supporting SIPs were developed for total suspended particulate (TSP). If the standards are changed, future SIPs will require methods to define source/receptor relationships that can distinguish between different particle size classes (e.g., fine and PM_{10} particles) and between chemical composition classes (e.g., sulfates, nitrates and organic/carbonaceous particles).

In the current program, a two-year plan has begun to produce an interim, short-term (1-hour and 24-hour averaging times), urban-scale PM_{10} (and/or FP) model and to produce an interim PM_{10} (and/or FP) mesoscale model. These models will soon be available to treat short-term concentrations related to transport/transformation from one or more large point sources (and possibly urban plumes). The purpose of the mesoscale model is to estimate regional or background contributions to the urban area. The models are presently formulated to handle secondary sulfate only. Evaluation of these models against existing data bases is planned along with a major field study to validate the urban particulate model. Additional modest field efforts will characterize primary sulfate emissions from residential/commercial sources, regional background contributions and fugitive emissions from vehicular traffic.

In 1983, a three-year effort to improve the interim urban scale and mesoscale aerosol models will begin. It will include additional chemical conversion modules, a visibility module and the best available values for transformation rates, dry deposition rates and dispersion parameters. Data from a Philadelphia field study (including a source inventory) will be processed and used for evaluation/validation of the improved models. Additional field efforts will continue to characterize primary sulfate emissions, regional background aerosol contributions and fugitive emissions from vehicular traffic. Various chemistry modules will be developed for distribution in 1984/1985. The improved urban and mesoscale fine and PM_{10} models will be completed in 1986.

Large point and area sources produce impacts on air quality over long distances, often affecting other states and countries. The ability to determine the effectiveness of alternative control scenarios in meeting acceptable ambient levels requires an adequate regional/long-range particulate model to predict ground-level concentrations of fine and PM_{10} particles over distances up to 1000 km.

One multi-state field study has been conducted during a period of prolonged polluted conditions in 1980 to establish the first available data base for evaluating regional-scale particulate models. A second field study is scheduled for 1984. The program to produce a regional-scale model for fine and PM_{10} particles will result during 1983 in an interim model which treats primary and secondary sulfate. Model development will continue with the incorporation of appropriate physical and chemical modules associated with particle production SO_2 to sulfate transformation and loss, into the EPA regional photochemical model. A major field study will be designed to provide a data base for the evaluation and verification of the regional particulate models. The field study is planned for 1984 and the evaluation and validation for 1985-1986.

A number of users, including state and local environmental agencies, EPA regional and regulatory offices and other agencies require air quality models for the assessment of new sources, modification of existing sources and other control strategies. The user's network for applied modeling of air pollution (UNAMAP) was established to provide these users with new applied modeling techniques in the form of computer codes and user's guides. The UNAMAP system has expanded from an initial six models to 21 models in 1981. The system will continue to be updated for use by the Office of Air Quality Planning and Standards (OAQPS) and others. Several new models will be added in 1983, including the interim models developed for urban and regional scales. In addition, a systematic assessment of EPA-recommended models will be performed to ensure that all of these tools are adequate for use in environmental decision-making processes (e.g., permitting, siting, SIP, PSD, visibility). Research producing air quality models for complex terrain, long-range transport and transformation, long-range tracer techniques, photo optics, visibility and residential heating are described in the energy chapter.

Monitoring Systems and Quality Assurance

The monitoring portion of the gases and particles research program has three major objectives: (1) to develop less expensive, more reliable tools for measuring both criteria and noncriteria pollutants in both exhaust gases and ambient atmosphere; (2) to assure the quality of measurements taken by the EPA and by state, local and international environmental regulators; and (3) to maintain the particle monitoring network, which provides data on particle loadings nationwide.

Improved monitoring tools can lead to dramatic improvements in the cost-effectiveness of environmental enforcement activities. For example, several states and regional programs are investigating the use of source self-monitoring to demonstrate compliance with emission limits. Improved monitoring systems for ambient air, stationary source emissions and personal exposure will be developed and/or tested. Major new systems will be available in 1982 for monitoring particles less than 10 microns in size in ambient air. Reference and equivalent methods for monitoring specified pollutants will continue to be prepared for the Federal Register.

Sensitive yet reliable and inexpensive methods of measuring pollutants are being developed for both in-stack and remote sensing. These include sampling strategies in cyclonic-flow situations, uses of UV-TV and IR-TV for remote sensing, Lidar for opacity measurements and tools to classify particle sizes and collect inhalable particulates.

In addition, airborne laser systems will be used to characterize aerosol distribution in the troposphere, to monitor long-range transport of polluted air masses, and to determine particle production, depletion, and transport within plumes.

Quality assurance (QA) support is essential to assure that advances in monitoring tools and methods are usable by, and useful to, environmental programs. Research in this area will give users the necessary performance specifications, audit devices and procedures for correlating the monitor value with pollutant emissions levels. The program will provide quality assurance for NSPS regulations and will aid regional offices in SIP and consent decree formulation.

The quality assurance program provides support to state and local agencies and regional offices as required to implement 40 CFR 58, state and local Air Monitoring Stations/National Air Monitoring Stations. This involves maintaining a repository of quality control reference samples, developing standard reference materials, verifying certified reference materials, carrying out semi-annual performance audits, auditing continuous source emission monitors, providing QA support for the Office of Air Quality Planning and Standards, and implementing the Agency-wide mandatory quality assurance program.

In addition, the Quality Assurance Handbook will be updated and a system for receiving, analyzing and reporting precision data will be developed and proposed in 1982. Workshops will be provided for state and local personnel on implementing regulatory quality assurance requirements. Audit verification centers will be maintained where agencies can have their calibration and audit standards verified, and reference samples will be provided.

This research program also supports the nationwide inhalable particulate network. The results from this network will be used to determine the relationships between various sizes of particles to evaluate the impact of a new inhalable particle air quality standard.

Health Effects

The overall objective of the health research sub-program in gases and particles is to provide techniques and information that can be used to improve the estimate of risk to humans resulting from the simultaneous inhalation of gases (criteria and/or non-criteria) and particles (organic and/or inorganic). Primary air quality standards are established to protect human health. The health effects research sub-program provides data for the criteria documents upon which standards are based. Health effects research includes controlled human exposure tests and animal toxicology tests. Work will be done on the acute and chronic effects of different particle sizes and of particles in combination.

Fairly complete data bases exist for SO_2 and lead health effects. More work is needed to study the human health effects of particles, alone and in combination with gaseous pollutants. An increase in emphasis on the health effects of particle size (and associated chemical characteristics) is required in order to improve the risk estimates required for regulatory decision making.

EPA research in this area stresses animal toxicology and clinical studies. Epidemiological studies germane to air quality are left to health agencies such as the National Institutes of Health (NIH) and academic institutions. EPA's animal toxicology work includes acute and chronic effects of particles of less than 2.5 microns and from 2.5 to 10 microns in size. Particles such as ammonium sulfate, iron oxide and kaolin clay will be studied alone and in combination with gases. Normal and respiratorily (elastase) impaired animals will be exposed and examined for pulmonary, biochemical, immunological, pathological and hematological effects. There is strong evidence indicating that exposure to some particulates can impair an organism's ability to withstand viral infection. Therefore, models are being developed and refined to allow quick and efficient extrapolation data from animals to man. Other models will help to determine the extent to which exposure to these pollutants increases susceptibility to viral infection.

In human studies, healthy subpopulations and at-risk populations will be compared for exposures to sulfate and nitrate aerosols alone and in combination with ozone, nitrogen dioxide, and sulfur dioxide to search for threshold levels at which clinically significant health effects appear. Health effects will be determined by changes in pulmonary and cardiovascular function and in biochemical and immunological measurements made on blood and tissue.

Animal studies will investigate normal and impaired animals using pulmonary, pathological, hematological, immunological and biochemical indicators of response. Regional deposition of particles in the lung will also be studied to assist in the development of dosimetric extrapolation models.

Scientific Assessment

The scientific assessment program is responsible for integrating all of the relevant scientific information necessary to produce criteria documents. Since these documents are the major technical input into the standard-setting process, the information in them must be accurate. Part of this effort includes a careful screening of the technical data to ensure that only reliable information is used in the criteria document.

For example, the lead document is currently undergoing update and will be available for external and Science Advisory Board (SAB) review in 1983. The final document will be produced by 1984. This document will be a complete, comprehensive and accurate summary of current knowledge about the relationships of airborne lead to humans and their environment.

Long-term Research

Long term exploratory research in support of the gases and particles research program has addressed a number of major issues including: sulfate, nitrate, and organic aerosol formation kinetics; atmospheric aerosol processes; chemical composition of urban size-resolved aerosols; volatile aerosols; deposition monitor development for acid gases and aerosols; source-visibility relationships; nitrogen oxide reactions to produce nitric acid and ammonia influence on aerosol formation; and organic acid additives to wet scrubbers. Future research will continue to expand the scientific base for the rest of the gases and particles research program.

MAJOR MILESTONES

- Update users guide for validated air quality simulation models - 5/1983
- Effects of sulfate and nitrate aerosols on at-risk subjects - 10/1983
- Develop and test long-range fine and inhalable particulate air quality simulation models - 10/1983
- Effects of combinations of gases and aerosols on human viral infectivity - 10/1983
- Methods to apportion particulate mass to specific emission sources - 8/1984
- Complete lead criteria document - 10/1984
- Quantify economic cost of materials damage from gases and particles - 10/1984
- Effects of SO_2 on growth/yield of agricultural crops - 4/1985
- Develop and test urban particulate models - 8/1985

RESOURCE OPTIONS

1982 Current Estimate 25.6

Growth	1983 Projected	1984 Projected	1985 Projected	1986 Projected
No	23.3	23.3	23.3	23.3
Moderate	23.3	23.9	24.6	25.4
High	23.3	24.6	26.0	27.6

Figures are in millions of dollars

No growth. Health research will focus on controlled human exposure to combinations of gases and particles. Modeling resources will address source receptor air quality dispersion parameter development. Monitoring support will continue at present levels.

Moderate growth. In the health area, focus will remain on clinical exposure studies, and where possible, extrapolation of animal toxicology to human effects. In modeling, focus will continue to be on source receptor air quality models as a means to evaluate SO_x/particle control strategies. Monitoring will be maintained at current levels.

High growth. Health research will be expanded in the clinical area as well as in animal toxicology. Extrapolation from high dose to low dose and across species will receive additional attention. Work on source/receptor air quality modeling will be increased. Monitoring efforts in support of regulatory action would receive greater emphasis.

OXIDANTS

INTRODUCTION

Atmospheric oxidants include a complex of substances which are either emitted from pollutant sources or are the result of in-air chemical reactions involving nitrogen oxides and volatile organic compounds (VOC). These oxidants include ozone (O_3), nitric acid, aldehydes (including formaldehyde), hydrogen peroxide, ketones, organic acids and many other substances. Ozone is the most significant of these oxidants.

The reactions which form oxidants are also of concern to other EPA research areas. For example, the gases and particles program includes studies of the atmosphere formation of fine aerosols and particles. Some of the volatile organic compounds are, because of their toxicity, under investigation under the hazardous air pollutant research program. Likewise, mobile sources are a significant source of oxidant and nitrogen oxide pollutants. These are addressed in the mobile sources chapter.

Objectives

The oxidants research program has six objectives. These are to:

- Support the national air quality standard-setting process by producing criteria documents for ozone and nitrogen oxides.
- Conduct research to provide health and welfare effects data, on ozone, nitrogen dioxide and other products of atmospheric photochemical reactions.
- Provide validated models for use in the development of state implementation plans for ozone and nitrogen dioxide.
- Provide scientific data on control technologies for volatile organic compounds and nitrogen oxides to support both state implementation plan development and the new source standards program.
- Provide sampling and analytical methodologies, new monitoring methods, and quality assurance procedures, as needed.

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LEGISLATED RESPONSIBILITIES

Under Sections 108 and 109 of the Clean Air Act as amended in 1977, EPA sets national ambient air quality standards. Primary standards protect public health, and secondary standards protect public welfare. Once standards are set, the states are responsible for developing an implementation plan (SIP) indicating how they intend to achieve the required standards. EPA provides guidance to the states in developing their implementation plans and is required to periodically review the standards it sets. Air quality standards have been established for two pollutants (ozone and nitrogen dioxide) addressed by the oxidants research program.

New standards are considered, or existing standards are reviewed (every five years), based upon documentation produced by EPA's research program. These documents -- called criteria documents -- set forth the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects of the pollutant in question upon public health and welfare. For example, the ozone standard will be reviewed in 1984. Since the criteria document requires nearly two years to produce, work has already begun on its production.

With respect to the state implementation plans, EPA is focusing efforts on providing guidance to states for controlling emissions of volatile organic compounds (VOC) -- a major oxidant precursor. Because of the magnitude of the ozone problem in many areas and the fact that many states have attainment date extensions to 1987, continued research support for developing guidelines for volatile organic compound control technology may be needed over the next five years.

Under Section 111 of the Clean Air Act new source performance standards can be set for new or modified source categories that emit criteria or, in some cases, non-criteria pollutants. Standards for a given type of source must reflect the best control technology (considering costs and other factors) that has been adequately demonstrated. The performance standards must, therefore, be based on up-to-date information regarding available control technology. To be useful in a decision-making context, this information must include removal efficiency, economic considerations, energy penalties and non-air environmental impact. New source performance standards exist for a number of sources of volatile organic compounds and nitrogen oxides (NO_x) while a number of additional standards are in preparation. In addition, the current standards must be periodically reviewed.

Also, for those areas granted ozone attainment date extensions past 1982, a "second-phase" SIP demonstration must be submitted by July 1982. Research on urban and regional photochemical modeling will be needed over the next several years to support the SIPs in major problem areas such as the Northeast, Los Angeles and the Gulf Coast.

RESEARCH STRATEGY

In working to provide the technical information, control technologies and support necessary for environmental managers to carry out their legal mandate regarding oxidants, the EPA research program conducts activities in three major research areas and two support areas. The major research areas are:

- Determining exposure and effects of oxidants and NO_x on human health and ecosystems,
- Producing reliable and useable air quality models and monitoring methods, and
- Developing and proving NO_x and volatile organic compound control technologies.

The support areas, in common with many of the other research programs described in this report, are quality assurance, and long-term exploratory research.

Our research plans and strategies, as they relate to oxidants, are discussed below.

Exposure and Effects

The exposure and effects program develops information to be used in the updating of criteria documents and the improvement of air quality standards. Research is planned to provide two types of data -- on health effects and on environmental effects. This data will be used in a third sub-program, called scientific assessment, to produce pollutant criteria documents.

The environmental processes and effects program will produce technical information and guidance on the effects of various O_3 and NO_2 air pollution levels on economically important agricultural crops. A major report relating O_3 and NO_2 concentrations to crop impacts on a region-by-region basis is scheduled for 1985.

The strategy of the health effects program is to provide the health effects information required to update the criteria documents for ozone and nitrogen oxides. In addition, information will be developed to describe the public health effects associated with other photochemical oxidants which are not regulated. Such compounds include aldehydes and peroxyacetyl nitrate.

Research areas which are considered appropriate to provide a reduction in the uncertainty in estimates of risks to public health associated with exposures to photochemical oxidants include the following:

- Evaluation of the health significance of clinical indicators of biological response (coughing, chest tightness, etc.).
- Characterization of responses of sensitive populations (youth, aged, pregnant).
- Characterization (synergism, antagonism) of the effects of multiple, simultaneous stresses such as temperature and/or activity.
- Improvements in estimates of risks associated with long-term low-level exposures especially in the range of present standards.
- A reduced but still significant effort to improve the capability to use animal data to estimate human risk.

EPA's human health studies will emphasize the effects of multiple stresses and sensitive population groups. Biological (animal) studies will be directed to improved models for quantitative extrapolation to estimate risks to humans, to indicate appropriate indices of biological significance of low-levels and to understand chronic effects on defense mechanisms. In both areas, emphasis will be on biochemical indicators and immune defense mechanisms.

Specifically, by 1984, results of major research efforts are expected to:

- Develop a biochemical model for O_3 uptake in rats,
- Determine the effects of NO_2 on viral activity in humans,
- Identify the ozone threshold in normal subjects, and
- Determine systemic effects of oxidant exposure on human populations at risk.

The scientific assessment program ties together in a decision-supporting format (criteria documents) reliable information in support of the standard-setting process. The next planned criteria document addresses ozone and related photochemical oxidants, and is scheduled for completion late in 1983.

Each of the existing national ambient air standards is on a staggered five-year update schedule. In mid-late FY-83, it will be time to initiate planning for the next review of the air criteria document for nitrogen oxides. Typical air criteria updates take two years to complete.

Air Quality Models

The models and techniques developed under this program are the mainstay of the oxidants regulatory effort. Research in this area produces four types of products: urban models, regional-scale models, data on biogenic compounds and their relationship with ambient ozone levels, and guidance to air pollution officials on the application and use of air quality models.

Adequate urban models of ozone air quality are essential in the evaluation of state implementation plan regulatory strategies. Analysis of several existing chemistry submodels indicates that their use could introduce errors in predicting ozone air quality patterns. Specific inadequacies of existing mechanisms are: (a) they do not accurately predict the effects of organic reactant compositon changes upon ozone yields, (b) they do not treat reliably the role of aromatic organics, and (c) they do not predict accurately non-ozone oxidants such as HNO_3 and formaldehyde.

In addition, these existing ozone air quality models cannot be used to model NO_2. Such a capability would be useful for the revision of NO_2 state implementation plans. In response to these shortcomings, a chemistry submodel will be developed that accurately treats the atmospheric chemistries of paraffinic, olefinic, aromatic and aldehydic emissions, and predicts the effects of organic emission composition changes on ambient ozone and NO_2. During 1984, a mechanism will be delivered to dispersion modelers which predicts the formation of PAN, HNO_3, aldehyde, ozone, NO_2 and other major oxidant-related pollutants.

A first generation regional-scale (up to 1,000km) model for ozone has been developed and is being evaluated for the northeastern U.S. The regional model supports state implementation planning and EPA's air regulatory program. It is scheduled for completion in the 1985 - 1986 time frame.

The regional model will serve as follows. It will provide inflow boundary conditions of ozone and its precursors from major upwind emission centers (usually other urban areas) to the urban scale model used in assessing control plans within the urban area. The model will also allow decision makers to evaluate the impact of oxidant control plans of individual cities from a regional perspective as well as provide the opportunity to assess a regional approach to oxidant control planning. In this way the contributions of ozone transport from one area to another can be taken into account. In addition to ozone problems, this regional modeling approach will address other air pollution problems. In the gases and particles and acid deposition research area, aerosol chemistry submodules are being developed in a way to be adapted to this regional model development program. The contribution of biogenic emissions to regional oxidant production will be assessed with the use of a regional scale ozone model. While there is a significant amount of information on the anthropogenic sources of ambient ozone precursors, very little is known about the contribution of natural sources. While it is known that isoprene and terpenes (hydrocarbons emitted from vegetation) can produce ozone under certain laboratory-controlled conditions (e.g., smog chambers), the information is not available to allow for a quantitative assessment. What data does exist regarding biogenic emissions is often conflicting. For example, measurements of ambient hydrocarbon (HC) concentration did not agree with the predicted concentration based on emissions factors. The inconsistency of the data may be due to erroneous ambient HC concentration measurement in urban and rural areas, erroneous emissions factors used to calculate the theoretical concentrations, different biogenic HC than predicted, or erroneous extrapolation of small-scale measurements to large-scale emissions levels.

It is the strategy of this research effort to determine accurate biogenic hydrocarbon emissions factors using a variety of vegetation under a controlled set of environmental factors. Smog chamber studies using terpenes and isoprenes will be used to determine the ozone-forming potential of these biogenic hydrocarbons. Once accurate emissions factors have been developed, the contribution of biogenic hydrocarbons to ozone formation can be predicted using the regional-scale model described above. A combination laboratory and field program will be conducted.

Longer term research will focus on developing a better understanding of fundamental chemicals and physical processes of the atmosphere. Emphasis will be on developing more accurate chemical mechanisms for the formation of ozone and non-ozone oxidants such as peroxyacetyl nitrate and on developing and validating new techniques to acquire accurate emission inventories of ozone precursors for all major source categories.

To make this research information directly useful, authoritative guidance will be provided to air pollution officials in EPA's program offices and state/local governments. These guidance documents will address the application and use of air quality modeling techniques in evaluating the effectiveness of control strategies. These efforts will be flexible enough to satisfy the individual needs of the user community.

Control Technology

Major regulatory decisions regarding both State Implementation Plans, New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants are based, to a significant extent, upon an understanding of the costs and efficacy of available pollutant control technologies. The control technology program will continue to review and update existing NSPS on the basis of the best engineering information presently available on control approaches to meet existing or revised standards at the least burden to industry.

While NO_x control technologies will continue to be assessed, the main focus of this program is on mechanisms to control VOCs. Many areas of the country are in violation of the national ambient air quality standard for ozone, one of the major oxidants. Volatile organic compounds are major precursors of oxidants in the atmosphere. Hence, control of these compounds is a prerequisite of oxidant control.

Volatile organics are emitted by many industrial processes, including surface coating, refining, chemical production solvent use, and gasoline handling and marketing. At this point, however, there is a lack of reliable data on demonstrated, cost-effective and energy-efficient control technologies for many medium and small sources of volatile organics.

This research program is testing the two most promising control techniques for volatile organics. The carbon adsorption system is being evaluated for industrial applications, and data will be made available regarding its cost-effectiveness and energy efficiency in controlling both volatile organics and hazardous air pollutants. The other major technology -- catalytic oxidation -- is also being evaluated. The results of this research will be determinations of the capabilities, costs and efficiency of these and other control technologies such as thermal oxidation, flaring, capture systems and material substitution. This information will be made available to support regional and state efforts to implement controls for large numbers of VOC-emitting industries so as to attain ambient air quality standards.

Quality Assurance

As required under the Clean Air Act, the oxidants research program provides for quality assurance and audit support for the rest of EPA and for federal and other laboratories. Monitoring support is provided to the air-program offices and regions, and monitoring equipment and methods are developed.

Most quality assurance support is of a continuing nature. The program supports the National Standards Laboratory, maintains standard reference materials and provides gas samples, permeation devices and flow rates, traceable to NBS standards. It conducts the National Audit Program and provides extensive short-term and quick-response monitoring support for EPA's air standards office.

Other tasks involve special developmental efforts. The National Atmospheric Pollutant Background Network, for example, is a multi-year effort which will provide the background data necessary for reviewing state implementation plans and for testing of regional air pollutant models. This study is scheduled for completion in 1983. For field measurement of ozone, a UV photometer will be developed as a reference standard. Also, methods for analyzing non-methane organic compounds will be evaluated and recommendations made to the Office of Air Quality Planning and Standards.

Long-term Research

EPA's exploratory research in oxidants seeks to build the fundamental knowledge base which underlies EPA's oxidant control strategy. Major active studies will include analyses of pulmonary effects of oxidant exposure in animals, chamber studies of the chemistry of NO_x species and a study on photochemical kinetics models which may be useful in improving air quality simulation models. Future research may include investigations of the effects of oxidants on sensitive populations especially those with cardiorespiratory impairment, and of the impacts on the photochemical problem of the use of alcohol in gasohol.

MAJOR MILESTONES

- Publication of criteria document for ozone and related photochemical products - 12/1983
- Collection of baseline conditions data from National Atmospheric Network - 1984-1985
- Development of improved chemistry mechanisms for urban scale ozone models - 1984-1985
- Determination of the effects of ozone and NO_2 on agricultural crops - 1985

- Development, validation and dissemination of regional scale ozone models - 1985-1986
- Determination of biogenic contribution to ambient ozone levels - 1986
- Evaluation of carbon adsorption and catalytic oxidation systems for control of volatile organic compounds - 1985-1986
- Provide innovative validated test systems and animal-to-man extrapolation models, relating exposure to ozone and NO_x to tissue dose - 12/1986
- Provide data on the occurance, exacerbation, and significance of cardiovascular, cardiopulminary, respiratory, and immunological disorders following exposure to ozone and NO_2 alone and in combination - 12/1986
- Provide data on respiratory, morphological, immunological and metabolic effects of NO_2 exposure in animals - 3/1987

RESOURCE OPTIONS

1982 Current Estimate 15.2

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	11.5	11.5	11.5	11.5
MODERATE	11.5	11.8	12.2	12.6
HIGH	11.5	12.2	12.9	13.7

Figures are in millions of dollars.

No growth. Emphasis will be on the evaluation and assessment of pollution control technologies capable of reducing or eliminating emissions of volatile organic compounds (VOC). Work on regional ozone modeling will continue to be of high priority. VOC monitoring equipment as well as audits and standards data for ozone, nitrogen oxides, and hydrocarbons, will remain priority research areas. Emphasis will also continue to be placed on the controlled clinical health program to determine the adverse effects of chronic, low-dose exposure to ozone and NO_2.

Moderate growth. Research on VOC control technology and monitoring equipment will be accelerated. The clinical health and ecological effects programs will remain at current levels. Efforts to add better chemistry mechanisms into urban models will continue at current levels. Work on regional ozone modeling will remain at current levels. The monitoring of background ozone will continue.

High growth. In addition to the above, studies of the health effects of non-ozone oxidants (e.g., PAN, formaldehyde) will be undertaken. The human (clinical) studies program will be accelerated to better ascertain the sensitivity of susceptible populations to exposures to ozone and nitrogen dioxide. Efforts will take place to model dispersion of ozone across regions, to identify the level of natural precursors of ozone and to better understand transportation-related emissions.

MOBILE SOURCES

INTRODUCTION

The control of emissions from mobile sources is a key element in the overall national program to protect public health and welfare from the adverse effects of air pollution. In keeping with its legislated mandates, EPA sets emission standards for selected pollutants from motor vehicles, establishes ambient air quality standards for airborne pollutants, including mobile source pollutants, and regulates the fuels and fuel additives which can be used to power motor vehicles. EPA also ensures that motor vehicles meet prescribed standards before manufacture, during manufacture, and while they are in use. In order to accomplish its mission in the area of mobile sources, the Agency requires research information on the amount of exposure which the population sustains from motor vehicle emissions, the effects of that exposure, and the level of risk incurred if the exposure continues. The Agency also needs some guarantee that the data used to make decisions about mobile sources are reliable and accurate, as well as sufficient to enable the states implementing the Clean Air Act to adopt and enforce cost-effective control measures. The mobile sources research program is responsible for amassing the research base necessary to enable the Agency to fulfill its mandates regarding mobile sources under the terms of the Clean Air Act.

LEGISLATED RESPONSIBILITIES

Section 109 of the Clean Air Act requires the Administrator of EPA to establish ambient air quality standards for certain pollutants, among them carbon monoxide (CO) which is emitted principally from mobile sources. Primary standards protecting human health and secondary standards protecting welfare are based on air quality criteria published and updated by the Administrator every five years. The criteria, as stated in Section 108 of the act, are to "accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of a particular pollutant in the ambient air." EPA's research program produces much of the data upon which these criteria are based.

EPA has established particulate emission standards for diesel-powered light-duty vehicles based on assessments of cost, technological feasibility and the contribution of diesel particles to the total suspended particulates (TSP). The Agency is required, however, to prescribe standards for those pollutants from motor vehicles which could endanger health and welfare (Section 202) (a) (1). While providing a fuel-efficient alternative to the gasoline engine, a comparable diesel-powered engine emits 30 to 100 times more particles. The combustion of any organic matter can produce a complex mixture of polycyclic aromatic hydrocarbons and other compounds, a number of which are carcinogenic. The problem has been to identify the biologically active elements in diesel exhaust, estimate the likely levels of human exposure and assess the cancer risk in humans posed by increased use of diesel engines. Experimental results using a variety of biological assays indicate that the responses induced by extracts of diesel particles fall within the range of responses induced by extracts of other products of incomplete combustion, such as coke-oven emissions. However, experts have concluded that even a major increase in the diesel fleet would not pose a serious threat to public health.

In light of the advance planning and huge commitments of capital that are necessary for synthetic fuel production, EPA, in keeping with the Section 211 mandate, must be in a ready position to assess the health risk posed by synthetic fuel combustion in motor vehicles. Thus, the test methods that will be developed through the mobile source research program must be available for this new application.

In determining whether any unreasonable risk to human health is posed by emissions from motor vehicles or their control devices, EPA is required to consider the effects of unregulated as well as regulated pollutants (Sections 202) (a) (1) and 202 (a) (4). In many cases, such as gas phase hydrocarbons and nitroaromatics, the task of capturing and measuring the pollutant poses a scientific problem. Once samples are acquired, the pollutant must be subjected to some kind of testing regimen to determine whether it presents a health risk. To support this regulatory mandate, the mobile source research program will provide the tools needed to sample, measure and test unregulated pollutants.

RESEARCH STRATEGY

For those vehicle classes where Congress has not specified emission standards, current mobile source emission standards for carbon monoxide, hydrocarbons and nitrogen oxides are based, in large part, on judgments of technological and economic feasibility. Before attempting to determine whether these standards adequately protect human health, it is necessary to know whether a reading from a fixed monitor provides an accurate picture of the levels of automotive pollutants to which people are exposed.

To respond to this problem, ORD is conducting a major study to determine actual human exposures to carbon monoxide. Carbon monoxide will be studied first because it is emitted almost exclusively from mobile sources, it is relatively easy to measure and concentrations vary greatly as a function of location. The project will make use of personal monitors to measure the concentrations of CO to which subjects are exposed at different times and locations. Human activity profiles will be developed for selected cities to determine where and when the overall population would be exposed to CO.

To assess how levels of other motor vehicle pollutants vary as functions of time and location, similar field experiments using personal monitors will be necessary. The applicability of CO as a surrogate for other mobile source pollutants will also be studied. The human activity profiles developed in the CO study should provide a tool for estimating exposures to other mobile source pollutants, including diesel particulate. We are also studying the effects of NO_x and ozone emitted from mobile sources. This research is described in the Oxidants Chapter.

Accurate human exposure readings are necessary so that EPA can more accurately evaluate the health and welfare effects of diesel particulate. Exposure assessment and measurement techniques, refined in the CO research program, will be adapted for use in studying diesel exhaust exposure.

The Agency is pursuing these research areas because results of other studies suggest that additional investigation is required to reduce uncertainty in the estimates of adverse CO effects. These adverse effects need to be addressed in evaluating the carbon monoxide ambient air standard and the automotive emission level that such a standard implies.

EPA has the responsibility to ensure that motor vehicle fuels and fuel additives will not have adverse effects on public health (Section 211). Development of reliable test methods that can be used to evaluate the effects of the fuels and additives is a major objective of the mobile sources research program.

The health effects of chronic exposures to CO concentrations at or near the ambient standard need to be established more definitively. ORD is responding to this need with clinical and animal toxicologic studies. The clinical studies will (1) assess the validity of a method for relating ambient CO levels in air to actual CO levels bound to the blood and (2) report on the effects on young and middle-aged normal people and on cardiovascular patients of exposures to various levels of CO and CO/ozone (O_3) mixtures. The animal toxicologic study will look for reproductive and neurobehavioral effects caused by CO exposure.

EPA will use data from diesel emissions research to evaluate the health and welfare effects of diesel particulate. Major components of the health research strategy include:

- Exposure of animals, via skin painting and intratracheal instillation, to diesel soot, coke-oven emissions, roofing tar emissions and cigarette smoke condensate. Since the last three substances are known human carcinogens, by comparing diesel soot with these substances, we expect to be able to estimate the soot's potency.

- Development of techniques to use short-term in vitro tests, such as mammalian cell tests, to identify the biologically active components in diesel exhaust and to verify the biological activities that were assayed using the Ames test system. This work will continue through 1983 and then be phased down. The result will be major reports on relative potency of diesel exhaust as a carcinogen and recommendations on the extent to which in vitro tests might be used for cancer-based regulation of engine systems and fuels and fuel additives.

The importance of the program extends beyond the immediate problem of assessing the risk of increased use of diesels. It represents a pioneering effort in the evaluation of the biological activity of complex mixtures for the purpose of supporting risk assessments.

The information on exposure and animal testing will be used to develop human risk assessments. These assessments are developed using the most appropriate animal testing data, extensive review of the data for completeness and adequacy, and the application of various statistical techniques.

Future trends in engine and fuel use for vehicles will require the development of tests that can be used to determine whether different engine systems, fuels and fuel additives pose an unreasonable risk to human health. In vitro tests are being developed and validated. These are to be used to characterize biologic activity and to screen emissions for further testing. If successful, such short-term tests will enable quantitative estimation of risks without having to go to larger and more expensive tests.

It is necessary to develop a testing scheme to assess carcinogenicity, mutagenicity, reproductive effects, and other chronic effects of fuels and fuel additives. The testing approach will include bioassays which identify the potential health risks in a practical and cost-effective manner. If any of the fuels or fuel additives are shown to be potential biohazards, supplemental tests will be considered to estimate the risk posed to humans. All aspects of the testing scheme will be developed in accordance with Agency risk assessment guidelines and will be subject to peer review by experts in each of the chronic effects areas.

Tier bioassays developed under this research effort presumably can be applied with little modification to the study of unregulated emissions. Eventually, these systems too can provide the basis for health risk assessments.

Chemical and physical data on diesel-powered vehicle emissions will be obtained in order to assess the impact of those emissions on the environment and to determine the ultimate fate of these pollutants. This information is needed to determine the actual levels of regulated and unregulated pollutants from vehicles operating under a variety of driving conditions such as high acceleration, low temperature or heavy loads. Also, there is a need to determine the abundance of the carcinogenic and mutagenic components of motor vehicle emissions in order to assess their impact on human health.

Characterization studies will be conducted to identify and quantify potentially harmful tailpipe and evaporative emissions from in-use gasoline and diesel-powered vehicles as well as from those using such synthetic fuels as methanol and m-gas. The studies will address both gaseous and particulate pollutants, particularly aldehydes, gaseous mutagens, NH_3 and HCN.

One problem area concerns identification and measurement of emissions (and components of emissions) from a variety of engines burning different fuels under varying operating conditions. Researchers will strive to answer questions regarding optimal control of mutagenic substances in diesel emissions and likely environmental effects of combustion of synthetic fuels. Emphasis will also be placed on characterizing the emissions from in-use heavy-duty diesel engines. Sampling gaseous emissions from engines has presented some difficulty. A method must be developed that does not change the biological characteristics of the exhaust, either by generating active artifacts or by suppressing biological activity.

Developing sampling and chemical analytical methods to characterize pollutant emissions from automobiles requires: (1) procedures for detecting chemical mutagens and hazardous pollutants in particle and gaseous tailpipe emissions for both diesel and gasoline engines and (2) procedures for real time analysis of priority unregulated pollutants, such as formaldehyde.

MAJOR MILESTONES

- Final report on bioassay of gaseous emissions from mobile sources - 9/1982
- Final report on evaluation of cardiopulmonary effects of CO and O_3 in healthy subjects and in patients with ischemic heart disease - 9/1983
- Report on respiratory carcinogenicity of diesel fuel emissions via intratracheal instillation - 9/1983
- Final report on comparative carcinogenicity of mobile source pollutants using mouse pulmonary adenoma model - 9/1983
- Determine the emissions from in-use heavy-duty trucks and buses - 9/1983
- Final human carcinogen risk assessment of mobile sources - 12/1983
- CO risk assessment - 3/1984
- Determine the CO and VOC emissions of prototype light duty diesel vehicles - 3/1984
- Publish results of study of activity patterns of individuals as related to exposure to air pollutants - 9/1984
- Final report on replication of EPA cardiovascular CO exposures in young, healthy, male subjects through measurement of systolic time intervals - 10/1984
- Assess pollutant exposure from control of diesel vehicles - 9/1985
- Publish results of CO studies - 9/1986

RESOURCE OPTIONS

1982 Current Estimate 5.6

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	4.5	4.5	4.5	4.5
MODERATE	4.5	4.6	4.8	4.9
HIGH	4.5	4.8	5.1	5.4

Figures are in millions of dollars.

No growth. Emphasis will remain on assessments of human exposure to motor vehicle pollutants and development of short-term screening tests for vehicle exhausts.

Moderate growth. Development of methods to isolate and measure mutagenic substances in motor vehicle exhaust will continue at their present levels. Efforts will focus on emissions from heavy-duty diesel engines and from engines powered by synthetic fuels.

High growth. Clinical studies of the chronic effects of exposures to carbon monoxide will be undertaken. Studies will focus on cardiovascular effects.

RADIATION

INTRODUCTION

The purpose of the EPA's radiation research program is to produce scientific data in support of EPA's Office of Radiation Programs. The program has two distinct components: ionizing and nonionizing radiation (NIR). Ionizing radiation activities consist of radiological monitoring in support of Department of Energy (DOE), nuclear testing programs primarily at the Nevada test site, and a quality assurance program which serves as a source of radionuclide and instrumental standards and radiochemical methods for analysis of environmental samples for use by both state and DOE contractor laboratories. The program also endeavors to assess the population's exposure to man-made radioactive materials through its monitoring and quality assurance efforts. The research on NIR or radiofrequency (RF) radiation is designed to develop data on the health effects and health risks posed by exposure to NIR frequencies currently present in, or to be introduced into, the environment. These frequency bands include broadcast radio and television, radar, land mobile radio, and microwave ovens.

Over the next five years, EPA plans to continue investigating both NIR and ionizing radiation. These efforts will support ongoing development of radiofrequency exposure guidelines, improve the data base on interactive mechanisms and health effects of continuous low level exposure to NIR and support the country's atomic energy activities, including those at the Nevada test site.

LEGISLATED RESPONSIBILITIES

Executive Order 10831 of 1959 (24 Fed. Reg. 6669) established the Federal Radiation Council (FRC). Statutory authority for the FRC is also contained in amendments to the Atomic Energy Act of 1954 (42 U.S.C. Sec. 2021) (h). Reorganization Plan No. 3 of 1970 transferred the FRC authorities to EPA. ORD's radiation research program supports the Agency's Federal Radiation Council authority. FRC authorities stipulate that the Administrator is to advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with states. Further, the Reorganization Plan also transferred certain regulatory and research responsibilities of the Bureau of Radiological Health as derived from the Public Health Service Act.

The NIR health research program directly supports the activities of the Office of Radiation Programs (ORP). Research needs are determined in conjunction with ORP. ORP is considering developing environmental guidance for radiofrequency and microwave

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radiation and has requested health effects data and evaluation. ORD scientists are providing a background health effects review and assessment document, which will serve as the primary health effects reference in developing the Federal Radiation Protection Guidance.

The principal thrusts behind the NIR program area are (1) the explosive growth in the employment of nonionizing radiation sources in communications, industry, and home applications which has raised the general level of population exposure to RF radiation and (2) a general absence of information on whether continuous, low level exposures to RF constitute a health risk. The public is exposed to individual frequency bands of NIR, within the range of approximately 5.6×10^5 to 4×10^{10} Hertz, each of which has different physical and energetic characteristics and may have variations in modulation as well. A variety of industrial, communications, consumer, and medical devices operate within this range, e.g., radio, television, radar, microwave relay systems, navigational aids, diathermy units, microwave ovens, and dielectric heaters and sealers.

In response to this accelerated use and to meet the Agency's mandate to develop Federal radiation protection guidance, the EPA NIR health research program was established. While several federal departments investigate other aspects of NIR, these other agencies have narrowly defined missions; their NIR research programs are directed toward specific frequencies, devices, and applications. EPA may address all NIR frequencies of concern for the protection of public health and the environment.

RESEARCH STRATEGY

Nonionizing radiation health research is inherently complex. Many biological systems are possibly at risk. The electromagnetic radiation spectrum cannot be thought of as a single pollutant; it is conceptually akin to a complex mixture of chemicals since each frequency may pose different potential risks. For a given exposure, dosimetry or energy absorption is a complex function of frequency and the size, shape, and orientation of the animal. Potential mechanisms of interaction, other than heat effects, are not yet known.

At present, a body of information is available on effects associated with acute or average exposures for continuous wave radiation. Over the next several years research efforts will be directed toward providing information on remaining questions. Data needs include the:

- effects on the mammalian nervous system and long-term pathophysiological effects,

- basic mechanisms of radiofrequency radiation interaction with living organisms,

- effects of modulation, intermittent exposure, peak versus average exposure, pulsed versus continuous wave radiation, and simultaneous exposure to multiple frequencies, and the improvement of available dosimetry.

The health effects program encompasses three basic study areas: (1) mechanisms, (2) NIR energy deposition modeling, and (3) experimental studies on cumulative effects, using animal models. Each of these is discussed in the following.

At high-level exposures to NIR, the basic mechanism operating to produce effects is heat. However, many effects are reported at exposure levels which do not produce detectable temperature increases in biological systems. This implies the existence of other mechanisms operating at low-exposure levels. Experimental studies will seek common mechanisms to allow extrapolation across a large portion of the frequency band. In addition, several reports in the literature allege effects on growth and function of bacterial and other unicellular organisms at specific frequencies. If frequency-specific response pertains also to multicellular and mammalian systems, different guidance strategies may become necessary. Research will be directed at developing an understanding of these underlying interactive mechanisms. The results will improve the Agency's capability to predict potential effects for given frequencies or exposure conditions.

Computer modeling of the interaction between radiofrequency radiation and humans which results in energy deposition in the body is a key element of the program in the period 1983-1987. The energy absorbed and its spatial distribution within the body are direct functions of frequency. Again, because of the breadth of the frequency spectrum of interest to EPA, computer techniques are the only feasible way to assess the potential hazard associated with specific frequencies in terms of energy deposited.

Humans act as nearly perfect antennae for the absorption of electromagnetic radiation energy in FM-radio and VHF-TV frequencies. Limited clinical data from studies of occupationally exposed people suggests that the effects of radio-frequency radiation are reversible given a respite; however, population exposures are continuous. It is not known whether such long-term, low-level exposures can lead to irreparable damage accumulating into observable effects or overt clinical disease or whether adaptation can occur. To help resolve this issue, a lifetime exposure system will be used to continuously expose rats to 500 MHz (UHF-TV). The resultant impact on life span (survivorship), morbidity, and cause of death will be examined.

ORD's ionizing radiation activity has two major components: (1) the conduct of an analytical radiochemical quality assurance program and (2) the conduct of the off-site monitoring program. EPA has a responsibility to assure that the research data which is employed in regulatory and other decision making is as accurate as possible. Over 200 state, local, and independent contract laboratories make radiation measurements which are reported to various local, state and federal organizations. The data used in assessments of population exposures to radiation is validated by a quality assurance program using National Bureau of Standards (NBS)-traceable radionuclides and other radiation standards. Under a Memorandum of Understanding with the DOE, EPA provides a comprehensive off-site radiological safety program for the Nevada test site and other locations of nuclear testing activity.

MAJOR MILESTONES

Annual reports will be produced on several major topics including: biophysical models to explain calcium release from NIR-exposed brain tissues, use of membrane properties as indicators of NIR interaction, mathematical models of absorption and distribution of NIR energy in humans, effects of chronic NIR exposure on immune functions, and provision of off-site support to the Nevada nuclear test site. Some major specific products are mentioned below:

- Report on sites in brain tissues affected by electromagnetic radiation - 1983
- Final report on behavioral effects of prolonged, continuous exposure to 970 MHz - 1983
- Report on the thermo-regulatory responses, both physiological and behavioral, of squirrel monkeys chronically exposed at low levels - 1983
- Report on extending calcium efflux studies to extremely low frequencies and to tissues other than the brain - 1984
- Verification of the NIR-thermal response computer model in squirrel monkeys - 1984
- Final report on mortality, cause of death, and morbidity in a population exposed to radar 40 years ago - 1984
- Determination of potential teratogenic and feto-toxic effects in mice repeatedly exposed in utero to varying levels of 2450 MHz microwave radiation - 1984

RESOURCE OPTIONS

1982 Current Estimate 2.5

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	1.6	1.6	1.6	1.6
MODERATE	1.6	1.6	1.7	1.7
HIGH	1.6	1.7	1.8	1.9

Figures are in millions of dollars.

No growth. The nonionizing radiation health effects program is being re-oriented to provide the remaining data required for issuance of federal radiation exposure guidelines. The program emphasis will shift from developing dose-response data in animals for selected specific frequencies to a greater focus on establishing information on biophysical interactions and mechanisms and on developing models to predict and interpret the significance of nonionizing radiation deposition for humans.

Moderate growth. The health program will continue its efforts as described above but will remain at a level of effort equivalent to the current health research program.

High growth. Radiation quality assurance activities will be increased.

PESTICIDES

INTRODUCTION

ORD's pesticides research program is designed to establish and maintain a sound, scientific basis for pesticide regulation and compliance activities. The program's focus is on developing knowledge and techniques as well as quality assurance procedures to assess potential health and environmental risks from pesticides. Results from this research effort will reduce the uncertainty under which regulatory decisions are made, increase the knowledge and understanding of the environmental and physiological phenomena involved, and improve the quality of pesticide risk assessment. In pursuit of this objective, ORD conducts field and laboratory research to expand the amount of accurate information available on chemical and biological pesticides, including their interactions with the environment and the identity of populations that are exposed. Additional ORD activities include the assessment of human and environmental risk and the provision of quality assurance support. Research activities which will be pursued during the next five years will emphasize the development, demonstration and predictive capabilities of protocols for identifying pesticide exposure and effects, and for defining consequent risks from pesticide use.

LEGISLATED RESPONSIBILITIES

EPA's regulatory responsibilities for pesticides are to review and register pesticide products that do not pose unreasonable risks to human health or to the environment. This process must take into consideration the economic, social, and environmental costs and benefits stemming from use of the pesticide. Risk is often quantified in terms of the number or probability of certain health effects in a given population, while benefits are most often stated in dollar valuations of such effects as increased crop yields, lower food costs, reduced chance of disease, or cost savings with respect to use of alternative control measures. Currently, EPA is in the midst of a massive project to review and re-register all pesticide products which are currently on the market. Approximately 85 percent of these products were originally registered before chronic effects (e.g., cancer, birth defects, gene mutations, etc.) of exposure to toxic chemicals were well understood. Their re-registration will, thus, require more thorough review of all test data for both acute and chronic effects. In many cases, the process will require the collection and review of the basic data itself.

These activities and the research activities needed in their support are mandated by several provisions of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended, and the Federal Food, Drug and Cosmetics Act (FFDCA), as amended. Section 20(a) of FIFRA authorizes EPA to undertake research necessary to carry out the purpose of the act.

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Section 3 (registration of pesticides) establishes a registration process to control the availability of pesticides through a premarket clearance or license. The 1978 amendments to FIFRA require that all pesticides on the market be reviewed and classified as to general or restricted use. For registration/re-registration, EPA will identify test guidelines which specify the kinds of health and safety information that manufacturers will be required to submit to EPA. EPA is then responsible for evaluating and assessing risk from exposure on the basis of the data compiled.

Research in support of Section 3 aims primarily at three high-priority areas: regulatory assessments, quality assurance, and development of pesticide testing protocols and exposure/assessment models. The primary need for pesticide research is to ensure that regulation is based on scientifically sound, legally defensible, information and methods which are acceptable to the public, cost-effective and up-to-date. Data having these characteristics are best generated by the registrants through the use of environmental and public health testing protocols of established scientific validity and regulatory relevance. This will require that some test protocols be developed and demonstrated to determine the exposure to, and effects of, the use of chemical and biological pest control agents.

Hazard evaluation uses research test data, ordinarily provided by the applicants for registration, to evaluate the extent of human health and environmental hazards. This process may require information about populations at risk, their potential exposure, and the adverse effects of that exposure. Techniques need to be developed for estimating exposures that result from approved pesticide uses, for predicting expected environmental concentrations in various media, for judging the efficacy of various regulatory control options in minimizing human and environmental exposures, and for improving the means to prevent excessive exposures.

Adverse effects of pesticides need to be defined and protocols developed and validated for measuring effects -- acute, subchronic and chronic -- on single organisms and on communities of organisms or ecosystems. The generation of all of this data by the registrants requires monitoring and quality assurance procedures which assure accurate test results.

In addition to registering and re-registering pesticides, EPA enforces compliance with FIFRA requirements by the pesticide-producing industry and by users and applicators of pesticides. The compliance program, conducted in cooperation with state agencies (Sections 23 and 24), includes registration of pesticide-producing establishments (Section 7), product sampling and label checks at production sites and in the marketplace (Section 9), certification and observation of pesticide applicators (Sections 4 and 11), and laboratory audits and inspections to ensure that good laboratory practices are being observed (Section 8). These compliance activities require cost-effective testing protocols and equipment. Support needs include instructional materials and technical assistance for: hazard situation sampling or analyses, teaching and assisting investigators in applying procedures in biological and chemical testing and quality assurance, and maintaining standard reference materials and instrumentation.

RESEARCH STRATEGY

ORD's research support includes transfer of research results, products or services to meet the Agency's needs and the utilization of the talent and other ORD resources to provide advice, consultation and short-term investigations as technical support. The research strategy addresses human risk assessment, environmental risk assessment, quality assurance, scientific assessment, and exploratory research.

Human Risk Assessment

Testing protocols will continue to be developed, improved and validated for the purpose of determining the exposure of humans to chemical and biological pesticides and to determine the human health effects resulting from the exposure to biological and chemical pesticides. This activity will concentrate in four research areas: (1) studies in experimental animal models to understand the absorption, metabolism, storage, and excretion levels of chemical pesticides, (2) development and improvement of sensitive test procedures for detecting possible harmful effects of chemical pesticides in humans, including adverse effects on fertility, the nervous system, the immune defense system, and vital organs, (3) development of testing protocols for biological pest control agents which will be used to evaluate possible human health hazards, and (4) extramurally funded field studies to determine the routes of exposure to humans.

Environmental Risk Assessment

The objective of environmental risk assessment research is to develop documented protocols and models for estimating the environmental risk associated with the use of pesticides. Research is conducted to determine the exposure concentrations to which non-target organisms are subjected and to determine the ecological effects of those pesticide exposures.

The development of predictive models is based upon a solid understanding of the human and environmental mechanisms and their kinetics (i.e., transport and fate, toxic effects, toxicology, environmental chemistry and biology, etc.). This objective includes basic research for the purpose of developing test protocols for environmental processes, such as sorption, microbial degradation, chemical transformation and movement. Field validation studies are underway to compare laboratory findings and predictive assessments with actual site conditions. These efforts will include field studies of fate and effects in surface and subsurface water supplies and in terrestrial systems.

The development of predictive capabilities to estimate the environmental hazards from chemical and biological pesticide use will continue. Mathematical models are being developed to identify ecosystem components and interactions sensitive to pesticides. These models will include the capability to predict the transport, transformation, bioaccumulation, fate and effects on non-target organisms in terrestrial, freshwater and marine environments. Currently, a model is available to determine the environmental concentrations in fresh water that would result from the use of a pesticide. The longer range goal of this objective is to expand this predictive capability to enable it to handle multi-media exposures and effects. While still requiring the registrants to submit data, such modeling may be useful in identifying the key data requirements and thereby reducing the need for some of the routine testing in the registration process.

Testing protocols also will continue to be developed for assessing the effects resulting from the exposure to chemical and biological pesticides on biota in marine waters, freshwater and terrestrial ecosystems. These protocols will be useful in determining the effects of pesticides on non-target birds, wild mammals, domestic animals, plants, aquatic organisms, and insects, including honey bees.

Quality Assurance

Quality assurance is a major pesticides scientific support activity. Quality assurance results in accurate and precise data being available for the regulatory decision-making process and federal/state enforcement activities. This activity maintains a repository of high purity pesticide analytical reference standards for EPA, other federal agencies, and private pesticides laboratories. In fact, the FDA relies upon this service for the standards used in its pesticides surveillance program to ensure that residues on food are within established tolerances. In addition, this function provides technical support to the Agency's field and contract laboratories in support of compliance activities and for human and environmental monitoring programs. ORD will provide scientific expertise to assure that the scientific data are of the highest quality.

Scientific Support

ORD will assist the Agency by providing scientific support through the review and conduct of human-health risk and exposure assessments in the areas of cancer, mutagenicity and reproductive effects. This activity will update the Agency's risk assessment guidelines and assure that they are consistent with those of other regulatory agencies. Technical expertise will be provided to assist the Agency in supporting regulatory actions and to review exposure and assessment methodology projects. The main emphasis of recent reviews and assessments has been on carcinogenicity, mutagenicity, reproductive toxicity and exposure assessments. Future activities will be broadened to include other chronic effects, such as behavior, cardiovascular, and neurotoxicity effects.

Data on pesticide effects will be provided for estuarine, freshwater and terrestrial organisms. The Pesticide Environmental Exposure Assessment Team estimates environmental concentrations and durations of pesticides in air, soil, sediment and various fresh and marine waters. This effort will provide data on pesticide transport, transformation, and bioaccumulation in estuaries, coastal waters, freshwater and terrestrial environments.

Exploratory Research

Research activities under the exploratory research program are designed to provide basic knowledge about pesticide transport and fate processes as these effect both humans and the environment. Fundamental knowledge is needed to support the development of more cost-effective testing protocols and data analysis and evaluation methods for both chemical and biological pest control agents.

Exploratory research will attempt to provide information on the major trends that could significantly alter the type and manner of pesticide use. Studies of emerging issues will provide initial risk assessments and estimations of the costs and benefits of alternative regulatory strategies.

MAJOR MILESTONES

Pest predation of crops, forests, and structures is an evolving problem. For example, new pests may be accidentally introduced, pests may attack different crops, or pests may develop resistance to control agents. Consequently, the major research milestones must assure that the continuing needs of the regulatory program are being met. There are three major types of high-priority pesticides research products which will be provided to the regulatory program within the next five years. These are: (1) scientific expertise to augment the resources of the regulatory office by providing assessments (such as on health and ecological effects) to fill gaps in data on chemicals under special regulatory review, (2) quality assurance services, including a repository of high-purity pesticide reference standards, to permit a high degree of technical precision for pesticide measurements, and (3) improved pesticide testing protocols and hazard assessment models to provide more effective ways to predict and evaluate the health and environmental risks associated with the use of pesticides.

Specific major research products scheduled for the next half decade include:

- Determine acute and chronic effects of selected pesticides on estuarine plants, invertebrates and fishes - 1983
- Determine effect of microbial adaptation on pesticide transformation rates - 1983
- Develop test methods and improve mathematical models for exposure assessments and transport and fate in ecosystems - 1983
- Improve test protocols for transport and fate of pesticides in marine coastal waters - 1984
- Define parameters and determine pesticide stress effects on selected ecosystems - 1984
- Complete health risk assessment guidelines, for EPA use, for mutagenic and reproductive toxicity - 1984
- Conduct field studies to validate laboratory-derived data and predictive mathematical models - 1985
- Develop methods for testing the effects of pesticides on estuarine communities and ecosystems - 1985
- Determine genetic stability and interaction of biological pesticides and the immunological effects of baculoviruses - 1985
- Determine effects of pesticide exposure on liver enzyme production and circulating alpholipoproteins in animals - 1985
- Determine health implications of biological pesticides with emphasis on genetic stability and interaction of baculoviruses - 1986
- Determine effects of pesticides on animal reproduction and development - 1986
- Assess the sensitivity and utility of adapting tests of peripheral nerve integrity as indices of toxic neuropathies - 1986

- Determine effects of age, sex, stress and species on the bioaccumulability of pesticides and develop a suitable animal model for extrapolation to humans - 1987
- Conduct field studies to determine pathways of human exposure to pesticides - 1987

RESOURCE OPTIONS

1982 Current Estimate 5.6

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	6.5	6.5	6.5	6.5
MODERATE	6.5	6.7	6.9	7.1
HIGH	6.5	6.9	7.3	7.7

Figures are in millions of dollars.

No growth. The types of institutions served by ORD's pesticides repository will continue to be those with immediate regulatory needs.

Moderate growth. Work will be slightly increased in the development of new or improved risk assessment methodologies, including field validation of exposure models.

High growth. Research will expand to develop new or improved methods for making human and environmental risk assessments, as will repository services and quality assurance to provide assistance commensurate with the needs of the program offices.

TOXIC CHEMICAL TESTING AND ASSESSMENT

INTRODUCTION

Research in the area of chemical testing and assessment is concerned with studying, evaluating, and documenting the health and environmental impacts of chemicals. The purpose of the research effort is, first, to provide a sound, scientific basis for regulating toxic chemicals and, second, to develop the tools for identifying potential hazards to health and the environment from the production, use, and disposal of chemicals.

The specific objectives of this research during the next five years are (1) to refine models and procedures for testing health and environmental effects and for characterizing chemical transport and fate, (2) to continue to develop guidance for evaluating test results as a basis for risk assessment, (3) to establish monitoring and quality assurance procedures which guarantee accurate and precise test results, and (4) to ensure that the most accurate, scientifically rigorous, and timely information available has been incorporated into supporting documentation for regulation.

The chemical testing and assessment effort is designed to directly support the Agency's needs for information and data collection methodologies to support regulatory activities mandated under the Toxic Substances Control Act (TSCA).

LEGISLATED RESPONSIBILITIES

TSCA provides information gathering, chemical screening, testing, and chemical control authorities, serving to protect health and the environment through a broad spectrum of regulatory actions applied to new and existing chemicals.

Section 4 (testing requirement) authorizes EPA to require manufacturers and processors to test already marketed chemicals for potential health and environmental effects, if the Agency can make certain findings as to the lack of data about the chemicals and their potential risk of significant or substantial exposure. The Agency is mandated to establish and anually review test protocols and methodologies for each test to the extent necessary to assure that the data produced will be reliable. EPA has decided that protocols are to be proposed initially by the persons performing the testing, subject to EPA's review and approval. EPA is developing testing guidelines which, among other sources, may be used by test sponsors as a source for the development of protocols.

Section 5 (premanufacture notification process) requires notification prior to the manufacture of new chemicals; EPA may by rule extend this to certain existing chemicals proposed for significant new uses. EPA reviews the new chemicals to identify those which may present unreasonable risks or for which additional information, including testing, should be developed. This process represents an information gathering mechanism crucial to the overall success of the TSCA program. Most notices contain little or no data relative to the health and environmental effects of the new chemical. However, the EPA review of premanufacturing notices must be completed within three months of notification, extendable to six months for good cause. Accordingly, techniques must be available to provide within the statutory period most of the data that is needed to perform risk assessments. These techniques must be based on established procedures that have been thoroughly evaluated on a standard data base.

Sections 6 and 7 (control for existing chemicals and imminent hazards) authorize EPA to limit the processing, production, transport, disposal, or use of a chemical if EPA determines that it poses an unreasonable health or environmental risk. Information concerning existing chemicals must be collected and reviewed to assess hazards for regulatory purposes. After review, EPA may take action to control high risk chemicals, and has done so for polychlorinated biphenyls (PCBs) and certain uses of chlorofluorocarbons (CFCs). Existing chemicals are evaluated as the need arises. Regulatory activities are determined by the urgency of potential hazard and the Agency's obligation to take action, as specified under TSCA.

Section 8 (information reporting) authorizes EPA to require submission by industry of reports concerning various aspects of chemicals, including commercial distribution and exposure, and health and/or safety studies concerning hazards which may be posed by the chemicals. What chemicals are produced, in what amounts, for what purposes, and with what consequences? Also, an inventory of chemicals in commerce has been compiled. If at any time a chemical or chemical class is deemed important enough to continue assessment although key information is lacking, a reporting rule will be considered to obtain the necessary data. The information derived through this means will provide a basis for developing risk assessments.

Each of the activities outlined above requires the development and application of validated measures and techniques to assure quality. Data bases used for risk assessments and regulatory decisions must meet minimum standards of precision and accuracy.

RESEARCH STRATEGY

The effort to address the research and information needs required by TSCA benefits from expertise already available from the EPA's Office of Research and Development (ORD). Research from ORD to support TSCA-related needs for chemical testing and assessment is provided in the areas of health effects, scientific assessment, environmental processes and effects, monitoring and quality assurance, and environmental engineering and technology.

Health Effects

Efforts in health research are to develop and validate testing methods in the areas of general toxicology, reproduction and teratology, neurotoxicology, mutagenesis, carcinogenesis, metabolism, and epidemiology.

In the first five areas, emphasis is on designing techniques and approaches to detect harmful effects of chemicals with cost-effective methods. In most cases, this concerns the development of a tiered scheme of biological tests. This approach utilizes quick and inexpensive preliminary tests to determine the need for more thorough studies. Initial screening would determine whether a chemical requires further investigation. If this screening (level one) establishes that the compound may pose a significant risk, but there are insufficient data to determine the extent of risk, the compound could be carried through a progressively (levels two and three) more detailed and expensive testing and assessment process where risk is analyzed. Level three tests are currently accepted as being definitive in quantitative as well as qualitative terms and are often lifetime or multiple generation studies performed at substantial cost.

Methods employed in the other two areas, metabolism and population toxicology, provide a means for determining whether a test system or species is predictive of human responses to a particular chemical. While the predictive capability of mammalian species is reasonably good, there are specific cases where test data cannot be extrapolated to man. As an alternative, exposures that occur in the general population must be related by actual internal dose determination (i.e., the actual partition of the pollutant and its metabolites within the body) to the data base of effects being measured by population toxicology studies. Research on metabolism will be continued to evaluate methods to determine which animal model best approximates the human response in order to evaluate absorption, distribution, and metabolism of chemicals and to assess the reaction of intermediate compounds with target organs. ORD will also continue to develop and validate methods in the area of population toxicology for determining effective internal dose through the use of chemical-specific dosimeters, blood, urine, and tissue analyses and the study of chemical-receptor interactions in animals and humans. Methods to determine indicators of adverse response will also be validated in order to better understand the biological significance of human test systems and to verify the ability of animal models to predict the human situation.

The new effort in population toxicology will be coupled with epidemiological studies conducted by others to validate the predictive capability of tiered system tests used for hazard assessment. This research will also enable better data to be generated for use in risk assessments. ORD's health research program has also initiated research efforts on structure-activity relationships in support of the pre-manufacture notification process.

Scientific Assessment

Review procedures and guidelines for conducting exposure and health effects assessments will be established. This is part of a larger effort directed toward establishing intra- and inter-agency guidelines for hazard, risk, and exposure assessment. These efforts include investigation and analysis of the procedures used by program offices within EPA and by other regulatory agencies within the federal government and development of standard factors, methods, and approaches where appropriate. Intra-agency guidelines for carcinogenicity and mutagenicity hazard/risk assessments and exposure assessments have been developed. Periodically, these guidelines will be reviewed to incorporate advances in the state-of-the-art. Carcinogen, Reproductive Effects, and Exposure Assessment Groups have been established to review and participate in the conduct of assessments required under TSCA.

Assistance will also be provided in the design of tests and procedures used to obtain data needed for health and exposure assessments. An extensive technical library on documented human health effects will be surveyed to provide data on specific compounds for use by the Office of Toxic Substances.

Environmental Processes and Effects

Improved and more cost-effective methodologies to assess ecological fate and effects of chemicals in the environment will be developed. Environmental research on toxic substances is being carried out under two categories: toxics-fate and exposure and toxics-ecological effects. Fate research is directed toward predicting more accurately the transport, transformation and persistence of toxic chemicals in the environment. Transport and fate methodologies will be used to develop data for testing of chemicals and in developing models for defining exposure concentration of chemicals. Ecological effects research is directed toward the development of testing protocols and hazard assessment models for defining toxic hazards. Exposure and hazard data will be used to estimate environmental risk associated with toxic chemicals. Environmental processes and effects research falls into five major areas.

Environmental fate. The Office of Toxic Substances needs standard advanced fate tests which precisely define laboratory test parameters so that test results can be extrapolated to the real environment. Such fate tests will provide exposure data for chemical risk assessments performed by the Office of Toxic Substances under Section 4 of the Toxic Substances Control Act. The program will address the specific need of the Office of Toxic Substances by developing methodologies for testing the fate, effects, and exposure of metal and organometallics in the environment. Such methodologies will enable the Office of Toxic Substances to carry out risk assessments for organometallics.

Environmental toxicology. Research will continue in aquatic toxicology. The Office of Toxic Substances uses the validated tests in test rule development for determining the hazard and risk of chemicals under Section 4 of the Toxic Substances Control Act. The Agency has developed several test methods for defining toxicity based on single species. System-level research will now focus on developing tests to define toxicity at the community level. The Office of Toxic Substances needs data on toxic effects at the ecosystem level when it evaluates the total toxicity of chemicals.

The development of culturing techniques will help to define and standardize species and diets for environmental effects testing. Such standardization of species will reduce the number of species, and hence resources, in the tests required to evaluate chemicals under Section 4 of the Toxic Substances Control Act. Research will continue to develop terrestrial toxicology which the Office of Toxic Substances needs to evaluate the impact of toxic chemicals on the environment, and ultimately, on man.

Development of predictive techniques. Exposure assessment models will predict exposure concentrations of chemicals in air, water, land, food chains, and multi-media environments. During 1983 work will be devoted to developing and validating such models. Data generated by these predictive methodologies will be used by the Office of Toxic Substances to perform risk assessments and risk benefit determinations on chemicals. The research program will continue to develop structure/activity methods for rapid toxicity and fate screening of existing and new chemicals and for extending hazard evaluation methods to additional classes or types of chemicals by comparative techniques. This approach will provide a cost-effective tool for the evaluation of the potential toxicity of new chemicals.

Comparative toxicology is designed to define (1) how much testing is needed for an adequate assessment of risk, (2) when one species can be used to test and predict for other species, and (3) which combination of species and toxicity tests can be considered most predictive. It will also involve the assessment of the relative sensitivity of various testing systems (single species, multispecies, microcosms, etc.). This research will reduce the number of species to be tested under Section 4 of the Toxic Substances Control Act, and thereby decrease the costs of testing.

Extrapolation from the laboratory to the real environment. ORD will continue to develop microcosms and model ecosystems to validate test methods and models. Microcosms provide a cost-effective tool to validate exposure assessment models and to screen the fate and effects of chemicals in order to implement Sections 4 and 5 of the Toxic Substances Control Act. This research will provide the capability to extrapolate from laboratory models and methods to the real environment.

The field validation program will focus on identifying tests and models that should be validated. Such field validation studies will improve the scientific basis of regulation conducted by the Office of Toxic Substances.

Indirect human exposure. Activities will focus on developing methodologies to measure and predict indirect human exposure that occurs through consumption of plants and animals that have become contaminated. The Office of Toxic Substances needs such techniques, along with direct exposure assessment data, to perform risk assessments on toxic chemicals.

Data base development. ORD will develop a specialized data base system by compiling, consolidating, and critically reviewing existing chemical and toxicity data. The information generated will be incorporated into a user-oriented data base to be used by the Office of Toxic Substances in evaluating complex data on new chemicals.

Monitoring and Quality Assurance

The monitoring systems and quality assurance program will continue to develop improved methods and protocols to more effectively ensure that the Agency's testing and evaluation procedures produce data of the highest possible quality. The Office of Toxic Substances needs sophisticated, chemical-specific, sampling materials and measurement instruments in order to evaluate and regulate chemicals under the Toxic Substances Control Act. The research program will support the Office of Toxic Substances through activities such as: continuation of the 1982 research to develop new sampling methods and improved high pressure liquid chromatography systems to analyze complex mixtures, publication of protocols that outline procedures to assure the quality and consistency of data when blood and urine tests are used in chemical exposure and effects evaluation.

While analytical methodologies exist for many compounds of interest related to evaluations under TSCA, in many instances, using these methodologies is extremely expensive and time-consuming. Accordingly, emphasis in development of analytical capabilities will focus on examining approaches to minimize or eliminate the extraction step in the analysis and adapt existing equipment to maximize throughput by mechanization. State-of-the-art analytical equipment will be installed in EPA analytical laboratories to advance research efforts for developing and applying analytical techniques to the most urgent TSCA-related monitoring problems. These techniques will be refined to the point that they can be transferred to other technical laboratories.

Emphasis in the field monitoring area will focus on measurement techniques that can be used to document environmental exposure at the receptor of interest. Monitoring systems techniques will be developed to establish concentration gradients, population activity patterns, and personal monitors.

Efforts in the first year of the quality assurance program will be directed toward establishing a bank of standard reference materials, a laboratory audit program, and a standardized system by which round-robin tests can be conducted. In the quality assurance research program, emphasis will be on providing standardized methods for handling biological material and developing appropriate field sampling protocols and guidelines.

Environmental Engineering and Technology

Support will be provided in assessing potential risks involved in the manufacture, use, and ultimate disposal (such as PCB destruction) of new and existing chemical products. This research effort provides technical expertise and specialized engineering for collecting and interpreting process or production data to evaluate toxic material emissions and determine release rates.

MAJOR MILESTONES

The emphasis of the research program has shifted significantly from previous years. Several of the methods, mathematical models, as well as monitoring guidance have been developed as a result of this program. As the development of these new methods and techniques is completed, the current research program will place greater effort on testing and validation as opposed to further new development.

To be useful, the accuracy and precision of measurements, methods, and models must be more clearly defined. Furthermore, the assumptions upon which monitoring guidance and predictions are made must be validated. Consequently, the projects and milestones presented here are oriented to testing and validation of newly developed techniques.

Specific milestones include the following:

- Verification of testing protocols for fiber release of commercial asbestos products and proposed substitute materials - 1982
- Guidelines for field validation of stream models - 1982
- Development of guidelines for reproductive effects assessments - 1983
- Final validation of structure-activity models to be used in rapid evaluation of environmental toxicity and multimedia fate for pre-manufacture review - 1985
- Development of multimedia (air, water, and land) monitoring systems - 1985
- Development of methods to monitor total human and environmental exposure - 1985
- Report on the development of structure-activity relationships to predict human health effects for use in pre-manufacture review - 1986
- Revision of Exposure Assessment Handbook - 1986

RESOURCES OPTIONS

1982 Current Estimate 31.2

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	26.6	26.6	26.6	26.6
MODERATE	26.6	27.4	28.2	29.1
HIGH	26.6	28.2	29.9	31.7

Figures are in millions of dollars.

No growth. Overall emphasis will continue on development, refinement, and application of methodologies for testing, characterizing, and evaluating the health and environmental fate and effects of chemicals. This includes developing procedures to determine whether a given chemical poses unreasonable environmental risks and, if so, to provide accurate, validated tests. The program will provide predictive capabilities for hazard assessments, will contribute to guidelines and protocols ensuring the adequacy of tests that may be used by industry and will support research into structure-activity relationships. The monitoring research program will provide methods development and validation as well as on-going quality assurance support. The engineering program will provide support for pre-manufacture notification review.

Moderate growth. The program will evaluate exposure levels and resulting hazard potentials to humans and the environment from a variety of pollutant concentrations and transport pathways. Molecular indicators of human exposure (i.e., presence and dose) will be studied for certain classes of compounds. Studies of metabolism and target organs will be accelerated and expanded to include multiple species. Research for use in predictive and risk evaluations will be accelerated; emphasis will be on promising techniques such as the use of chemical structure-activity relationships. Top priority will be given to the quality assurance program tailored to EPA's regulatory and enforcement activities.

High growth. Both the health and environmental processes and effects programs will accelerate research on predictive models. Such models will employ systems which take into account the multiple interactions of toxic chemicals as they move through the environment and their effects on receptor organisms, including humans. The health and environmental processes and effects programs will augment investigations into structure-activity relationships.

HAZARDOUS WASTE

INTRODUCTION

The solid and hazardous wastes program coordinates research efforts relating to the implementation of the Resource Conservation and Recovery Act (RCRA). Prior to 1980, the main focus of EPA's solid waste research program was on the collection, treatment, and disposal of all municipal and industrial wastes. Since that time, emphasis has shifted to focus on the more hazardous portions of those waste streams. This focus will continue for the next five years. Research into hazardous waste will be directed at developing basic scientific data on hazardous materials and at developing new methods for identifying, assessing, and treating hazardous wastes. Research into energy and mineral wastes will be limited, and may be phased out as early as 1984.

There is close coordination between the research conducted under the RCRA hazardous waste program and the activities supported under the superfund program. In essence, the dividing line between the two research programs is determined by the state of readiness of a particular technology or method to be used in environmental cleanup situations. If the technology is ready to be used and lacks only application and user-support tools, those tools are developed under the superfund research program. If, on the other hand, additional research is necessary to make the technology or method usable, that additional research is part of the hazardous waste program. There are some exceptions to this rule, based upon legislative mandate, which will become apparent in the following pages.

Because of the relative newness of the hazardous waste issue, there is a significant lack of experience and technical expertise in this area. This dearth of technical know-how affects the EPA and industry alike. The research conducted under this program will provide the scientific basis for the private and public sectors to: reduce the quantities of hazardous waste requiring disposal through process change, waste recycle and re-use, and waste treatment, ensure environmentally sound disposal and destruction of future wastes, and correct past mismanagement practices.

Objective

The overall goal of the RCRA hazardous waste research program is to provide the EPA program offices with the research they require to complete their regulatory, enforcement, and technical support missions. The research provides the scientific and engineering basis for the identification, characterization, monitoring and disposal of hazardous waste in an environmentally safe, yet economical manner.

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The program defines five major objectives:

Identification: Provide measurement methods and protocols, monitoring guidelines and a quality assurance program for use in the development and enforcement of regulations.

Treatment and disposal technology: Assess both existing and new technologies under new conditions. The goal is improved ways to reduce the quantity of hazardous waste through recycle and reuse, to destroy or detoxify hazardous waste through treatment, and to dispose of hazardous wastes in an environmentally safe manner. Technology for sites requiring remedial action will be developed and evaluated. Because of the scientific and technical expertise it will have as a result of these development efforts, ORD will also actively assist the Office of Solid Waste in reviewing individual permit applications.

Risk assessment: Produce the information and methods necessary to determine the magnitude of risks to human health and the environment resulting from mismanaged treatment, storage and disposal of hazardous waste. Outputs from this work will steer the setting of priorities, influence decisions about regulatory options, and serve as a basis for necessary enforcement actions.

Oil and hazardous chemical spills response: Develop the methods, techniques, guidelines, systems, and technology necessary to provide the agency with the capacity to respond effectively to emergencies caused by spills of oil and/or hazardous chemicals. This capability is required under the Clean Water Act, Section 311.

Long-term research: The exploratory research program provides for initial investigations into advanced technology areas. This research will help to develop the technology necessary to properly analyze and assess the impact of hazardous waste problems and to control them in the most effective manner.

LEGISLATED RESPONSIBILITIES

EPA's hazardous waste research is conducted in response to the mandates of the Resource Conservation and Recovery Act (RCRA) of 1976, and its amendments. The Federal Water Pollution Control Act (FWPCA) of 1972 and its amendments also directs some of the research, specifically the spills-related efforts.

Investigation of treatment and disposal technologies is mandated under Section 8001 of the RCRA. Such technology-oriented research supports the development of the regulations promulgated under Section 3004. In addition, technology research provides firms which treat, store and/or dispose of hazardous wastes with the tools necessary to comply with hazardous waste regulations.

Hazardous waste analysis, the essential first step in control, is a major priority of this research program. A waste is difficult to treat if it cannot be accurately characterized. Research supported by this program seeks to establish a sound scientific and legal basis for data required by Sections 3001, 3004, 3013, 7003, and 8001 of the RCRA.

Finally, in order to properly assess whether particular regulatory approaches would protect human health and the environment, reliable tools are necessary. Such tools will help environmental decision makers to gauge the potential impacts of various substances under various circumstances. The risk assessment program produces such tools based upon responsibilities contained in RCRA, including identification (Section 3001), standards applicable to storage, treatment, and disposal facilities (Section 3002, 3003, and 3004), permits (Section 3005), monitoring (Section 3013), and the "imminent hazards" authority (Section 7003).

The hazardous waste spills program supports Section 311K, the National Contingency Plan for oil and hazardous spills, and the Spill Prevention Control and Countermeasure Program as mandated by the Federal Water Pollution Control Act.

RESEARCH STRATEGIES

The research strategy required to achieve the previously stated objectives involves an integrated program which identifies and characterizes hazardous wastes, assesses the environmental and health risks they represent, and determines the techniques and technologies required to dispose of them in an environmentally safe and economical manner.

Waste analysis research is exceedingly important because of the general dearth of standardized methodology and techniques for sampling, identifying and characterizing potentially hazardous wastes. Without this capability, the risk assessment and subsequent program priority setting processes will be far less certain.

Risk assessment research provides the health and environmental data needed to help environmental officials set enforcement and clean-up priorities as well as to develop the regulatory program. Ideally, once a waste has been identified as potentially hazardous the documentation would be available to determine its health hazard, environmental effects, likelihood of transport through water and soil and persistence. Appropriate decisions can then be made with regard to waste treatment and regulatory options. Currently, not all of the required information is not available. The risk assessment sub-program together with an extramural effort being conducted by OSW, is producing this information, and is developing scientific evaluations of all available alternative approaches to specific problems.

Two of the hazardous waste sub-programs deal with control technology development and testing: the hazardous waste control technology sub-program and the oil and hazardous chemical spills response sub-program. The former develops various means of safely isolating various types of hazardous wastes as well as developing new methods for cleaning up sites where wastes have been improperly released into the environment. The latter sub-program produces information both on spill hazards and containment, and on clean-up and prevention techniques as they relate to water-borne spills. This information is packaged to be of immediate applicability in emergency or quick-response environments.

The final major research sub-program -- exploratory research -- goes into far greater depth in key areas to identify the basic physical, chemical and biochemical processes that determine the generation, environmental transport, effects and control of hazardous wastes. Breakthroughs in understanding these processes, when fed into and exploited by other research sub-programs, may contribute significantly to improving our ability to control hazardous wastes.

In the following sections, each of the above sub-programs are discussed, and the strategy with regard to priority areas of research is delineated.

Hazardous Waste Analysis

The ability to provide standard methods and guidelines for the analysis of hazardous wastes is essential to establish the level of risk of the waste and to define adequate control technology. Enforcement actions will rely heavily on obtaining scientifically accurate and legally defensible data.

Hazardous waste analysis research develops sampling and analysis techniques for wastes which are potentially hazardous. The present program is focused on the development and maintenance of quality assurance for the hazardous waste monitoring program, and the development of monitoring methodologies and guidelines. Research into the use of screening methodologies will increase in the 1983 to 1987 time frame. A major program will develop improved field sampling methods.

Monitoring guidelines will be developed for EPA regional, state and local use. These guidelines will include air, biological, groundwater, and exposure monitoring. Other guidelines will assist environmental program officials in site selection and evaluation. The guidelines will help to assure adequate, consistent, and cost-effective monitoring of hazardous waste efforts. "Interim" guidelines based upon available methodology and current knowledge are being prepared. As the interim guidelines are tested and the hazardous waste problems become better defined, improved guidelines will be developed, tested, and published.

Development, improvement, and evaluation of the sampling and analytical methods required for hazardous waste monitoring will receive high priority. This activity provides for the development of new methodology where none exists and for the improvement of the accuracy, precision, and reliability of existing methodology. It includes chemical and biological methods in field and laboratory applications. New techniques will be evaluated, and biological and exposure assessment methods developed. Some of these techniques are intended to reduce the time required for the analysis of wastes and to provide quality-assured data. A compendium of procedures for chemical analysis of hazardous waste will be issued and periodically updated to assure that the best known methods are available from the Agency's documents. Research will seek to improve bioassay methods for screening waste samples. The use of bioindicators to evaluate relative hazards will be assessed and methods for detecting and monitoring dioxins will be developed.

The quality assurance efforts will continue to develop standard reference materials and methods for analysis of complex matrices, and to improve and validate the detection limits of existing methods. The program provides for the research required to correct inadequacies that limit the quality of data from the current monitoring program. Quality control procedures for automated laboratory analytical systems will be developed. The quality assurance program will provide standards for calibration, reference solutions and samples, and will validate field sampling and analytical methods.

A major initiative planned for the next several years is a research effort into post-closure monitoring of hazardous waste sites. The new program will develop a multi-media systems approach to subsurface monitoring to determine the success of actions on RCRA-permitted and properly closed hazardous waste facilities. Initially the program will focus on in-situ sensors for monitoring the vadose and saturated zones. Remote monitoring systems such as photography, multi-spectral and thermal scanners will be investigated to determine their applicability to monitoring guidelines for closed hazardous waste disposal facilities. Cost-effective long-term monitoring will be a critical element in this research.

Risk Assessment

The research strategy for risk assessment includes the production of risk assessment documents for specific chemicals (scientific assessment), the determination of toxic effects on humans likely to result from exposure to hazardous wastes, the development of methods and data to define environmental transport and fate characteristics of hazardous wastes, the determination of likely ecological effects of environmental exposure to hazardous wastes, and the development of models to predict the impacts of various waste management procedures or disposal methods.

In addition to the activities mentioned above, the continuing research program is directed at developing a health effects data base on selected compounds and information on the subsurface transport and fate of hazardous wastes. In the near term, projects studying ecological effects and socio-economic effects will be added.

Beyond 1984, the emphasis of the risk assessment research program will be on assessment of health effects and on the estimation of exposure through transport and fate modelling. Within the health effects research area, screening and identification, relative risk evaluation of complex mixtures of hazardous waste samples, and human studies will make up the program. Subsurface transport and fate research will build upon prior drinking water media research, although it will go beyond drinking water concerns to address other health and environmental impacts.

Major efforts will develop and validate both test systems for screening wastes based on toxicity, and bioassays for describing the effects of hazardous wastes or complex mixtures on health. This research will produce a variety of outputs at several levels of technical detail. Health summaries are one- to four-page documents which provide qualitative adverse health impact information. A health profile is five to 15 pages in length and provides a limited literature search and inventory of health data for all significant health effects. Health assessments are comprehensive compilations (all known toxic effects) of health effects involving a search of worldwide literature, an evaluation of key studies, and can be 25 to 200 pages in length. These documents typically satisfy scientific and legal requirements for major regulatory action and are usually submitted for rigorous public and scientific review. A hazard assessment is similarly comprehensive, has quantitative measures of health toxicity and has an exposure component added to the health assessment portion. Its typical use would be to define the health hazard to a population. This type of document, with both the toxicological and exposure evaluations, represents the ultimate assessment output. Health hazard assessments, for specific chemicals will be provided, to further specify the potency of the chemicals listed in Appendix VIII (40 CFR Part 260) and for use in permit and enforcement situations. Health hazard assessments, together with exposure components, can be used to either qualitatively predict the nature of the hazard for a set of technologies and siting situations, or can be used to estimate the risk of potentially exposed populations. Special oversight and consultation will be provided to support new Agency guidelines for uniformity and consistency in exposure assessment procedures across the various EPA programs.

Finally, to determine potential exposure to hazardous wastes, information is needed on how these wastes travel through the environment. Research will be conducted on transport and fate, pathways to human exposure, and bioassay development. By the end of 1983, we will have initiated field evaluation tests of mathematical models of subsurface transport and fate. Subsurface geological environments will be evaluated in order to identify areas relatively suited or unsuited for land disposal of hazardous wastes. The rates of change caused by environmental processes will be determined for chemicals of special interest to OSW. The result will be more accurate estimations of multi-pathway human exposure. Environmental processes and effects research into terrestrial

Control technology

The engineering and technology program is designed to support regulatory development efforts at the federal, state and local levels, as well as regulatory reform efforts, by providing a technology base for reducing the quantity of hazardous wastes through environmentally sound destruction, treatment and disposal practices. This information is necessary to ensure that regulations promulgated under RCRA, section 3004, are based on sound engineering and scientific data, achieve maximum cost-effectiveness, and provide the regulated community with the tools necessary to comply with the regulations.

Improved treatment and disposal technology is necessary if hazardous materials are to be managed in a manner that is economically as well as environmentally sound. EPA treatment research strategy in the short term will be directed primarily at areas where industry research is not expected to be sufficient to meet needs. This includes the analysis of advanced techniques for incineration of hazardous wastes, improvement of air pollution control technology, development of improved leachate collection and plume removal systems, and determination of the compatibility of various liner materials with specific wastes.

For active hazardous waste disposal areas there are several areas where research will focus. First, various liner materials will be investigated to determine their mechanical strength and chemical resistivity when exposed to various types and mixes of wastes. The compatibility of various clays with acidic and basic wastes will be assessed. Various liner designs and leachate collection systems will be tested, and leachate removal and treatment methods will be assessed. System to scrub contaminants from soils and to concentrate contaminants from collected leachates and gaseous emissions will be developed.

Another major problem confronting active hazardous waste disposal sites is the plume of contaminated leachate which may be created in the groundwater. Methods for detecting and monitoring the plume will be developed and tested. Remedial action via plume removal and treatment will be investigated. Priority research in this area focuses on the development of methods to determine subsoil transport and fate of leachate, and of models which can be used to predict the movement of leachate plumes.

After a hazardous waste site is closed, two major concerns remain: how to securely cover the site to minimize the inflow of leachate-causing water, and how to monitor whatever leachate may be released. The major research priority with regard to covering or capping hazardous waste sites is to find a solution to the problem of subsidence. As the waste pile settles, areas will collapse beneath the cap. Research will seek to identify capping techniques and/or materials which will withstand the subsidence process without losing their integrity as water barriers. Other research will seek to determine the efficacy of such isolation techniques as grout curtains.

Research to optimize the performance of a secure landfill will be continued. The goal is to predict and control the movement of liquids and gases in and around a landfill. The sub-program will prepare reports on research for user manuals for permit writers, design engineers, and operators. Medium-term research will produce a manual for hazardous-waste landfill siting, design, and operation. Technical resource documents to predict the performance of landfills, surface impoundments and land treatment facilities will be revised as new information becomes available. Waste characterization and decomposition studies will continue. Containment systems and waste modification concepts to minimize the potential for pollutant movement are being evaluated. Design criteria will be developed for surface capping as a function of soil type, site topography and capping material. Ongoing remedial action efforts that involve in-situ waste stabilization are being monitored and studied to evaluate chemical fixation and solidification.

A significant portion of the hazardous waste control technology research effort entails the provision of technical assistance to industry, state and local governments for the design, construction and operation of secure landfills for hazardous waste. Field investigations will test the stability of mixed wastes. The resultant data will be correlated with laboratory-developed data to produce models which can, in turn, be used to predict the behavior of mixed-waste depositories.

In the present program, high priority is given to thermal decomposition research. This is a relatively new research area wherein increased knowledge should lead to the continued refinement and improvement of existing incinerator regulations. Research will continue to develop better sampling and analysis protocols or analyzers to be used to routinely test incinerators to ensure they maintain their destruction efficiency. In developing the measurement protocols, special attention will be given to on-line hotzone sampling techniques. These techniques will be studied, modified, and verified during pilot-scale test burns. In addition, priority will be given to ranking certain types of wastes according to the ease with which each can be destroyed through incineration. Such a ranking will be a valuable tool in testing the effectiveness of waste destruction of new and existing incinerations.

The incineration sub-program is also investigating the feasibility of firing hazardous waste in high-temperature industrial processes. Laboratory thermal decomposition analyses and pilot-scale destruction studies will be conducted to determine the conditions required for destruction of hazardous wastes. The products of this work will include guidance manuals and updated incineration and treatment technical support documents.

Technologies and techniques developed for other purposes are showing great promise when adapted to hazardous waste destruction. Under the innovative technology sub-program, research will be conducted to develop advanced hazardous waste treatment technologies. There is already sufficient information to support the start of bench-scale studies on advanced biological conversion processes, supercritical solvents and metals recovery using adapted metallurgical techniques. Work will continue through 1986 if results show promise.

Land treatment via spreading may be a viable waste management option for selected hazardous wastes with potential economic and environmental advantages over other options. The objective of the land treatment technology research program is to define the operating condition for the disposal of these wastes in an environmentally safe manner utilizing the natural biological, chemical and physical processes in the soil for the purpose of degrading, attenuating, or otherwise rendering innocuous those wastes receiving such treatment.

This part of the research program will continue to support the EPA program office and regions in developing RCRA regulations and reviewing applications for hazardous waste disposal facilities.

Spills response

When hazardous substances are released into the environment, it is the responsibility of local, state and federal response personnel to make the major decisions concerning the extent of contamination, clean-up priorities and selection of clean-up alternatives. These decisions will be based on the potential impact on public health and sensitive environmental areas. In support of this decision-making process, a uniform set of procedures employing state-of-the-knowledge and scientific information on transport, fate and effects of hazardous substances (released as well as those used to mitigate the contamination) will need to be developed. The basic scientific information to support development of these procedures will be provided through this program.

Many different technologies and techniques have been suggested to contain and clean-up spills of oil and hazardous materials. Under this program, clean-up options are tested and developed. Our evaluation test tank is used to simulate realistic water and shoreline conditions for testing and improving spill clean-up and shoreline restoration techniques. Guidelines will be developed which will establish ecologically acceptable residual levels of contaminants where criteria for extent of clean-up do not exist. Oil spill prevention techniques will be evaluated and user manuals and guidelines will be prepared.

The ORD will continue to provide in-house support to the compliance monitoring programs of the regions. Through the use of aerial photography, inspection teams will be able to identify problem areas before spills occur at transfer and storage facilities. The photography program will also continue to support the response to major spills by acquiring and analyzing aerial photography.

Long-term research

The long-term research program is currently active in innovative technology (these include a wet air oxidation process for destroying hazardous wastes, a super-critical fluids process for concentrating and recovering wastes, and the genetic engineering of yeasts for degrading hazardous wastes), waste detoxification, unit process analysis to determine waste characteristics, and non-point source control techniques. Additional research is planned to develop new methods for detecting hazardous wastes, including non-volatile pollutant analysis, biological and enzyme sensor systems, spectral reflectance and chemical electronics. Additional research may focus on organics recovery and destruction methods, determination of threshold factors for irreversibility of ecosystem damage, and long-term hazardous chemical biodegradation rates.

MAJOR MILESTONES

Numerous support activities will be provided to EPA enforcement offices and state and local officials. These include quality assurance programs, health assessment, population-at-risk hazard assessments, component exposure hazard evaluations, technical information and liaison functions, monitoring activities, and studies in direct response to OSW's RCRA requirements.

In addition to these continuing support activities, a number of major research products are planned. A few of those are listed below:

- Improved health risk assessment methods for complex mixture and multi-exposure situations - 7/1983
- Report on innovative hazardous waste disposal technologies - 7/1983
- Rapid response test methods for toxicity of complex mixtures -- interim report - 9/1983
- Guidelines for establishing acceptable residual levels -- interim - 9/1983
- Report on incineration of hazardous wastes in high-temperature industrial processes - 10/1983
- Monitoring guidelines for sampling and remote sensing of hazardous wastes - 9/1984
- Validate currently available population toxicology methods -- 9/1984
- Post-closure monitoring guidelines for hazardous waste disposal sites - 10/1984
- Oil spill control and clean-up methods --user's manuals - 6/1985

RESOURCE OPTIONS

1982 Current Estimate 29.5

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	29.6	29.6	29.6	29.6
MODERATE	29.6	30.5	31.4	32.3
HIGH	29.6	31.4	33.3	35.3

Figures are in millions of dollars.

No growth. Major emphasis will be on waste analysis, risk assessments and control technologies. Hazardous identification will initially focus on the development of sampling and analytical protocols, quality assurance, and evaluation of existing methods and procedures. Later work will shift toward waste characterization, exposure assessment, and the development of improved sampling and analytical methods. Control technology research will develop the information base that will support the permitting program for hazardous waste. Particular attention will be paid to evaluating thermal decomposition, containment, and other hazardous waste treatments. Risk assessments will be used to: (1) develop the criteria to support "listing/delisting" of hazardous wastes (2) adapt and develop techniques to assess risks from disposal of hazardous wastes and (3) make decisions regarding various disposal options for specific wastes.

Moderate growth. More emphasis will be on hazardous waste analysis in an effort to more rapidly develop waste characterizations, exposure and risk assessments, and new sampling and analytical methods. Control technology research will augment studies of thermal decomposition, control and containment of wastes and land disposal. Also, development of innovative techniques for destroying wastes will be augmented.

High growth. Research will focus on expanded monitoring techniques, control technology, and risk assessment with the objective of producing key results earlier than under the no-growth or moderate-growth options.

SUPERFUND

INTRODUCTION

Activities planned as part of the superfund program have two main purposes: first, to coordinate efforts related to hazardous substance response within EPA's overall research program, and second, to make available to both EPA offices and others dealing with hazardous waste sites the latest research information, in usable format, on discovery, control, monitoring and cleanup of hazardous material spills and uncontrolled waste sites.

This is EPA's newest major research area and its planners work closely with program planners and managers in the hazardous waste research and technology exchange area. The efforts of the superfund program aim at quickly assembling and adapting existing state-of-the-art technology and information for use by on-the-scene coordinators and state and local personnel. In contrast, the focus of the hazardous waste program described in chapter nine is on research and development of new hazardous substance science and technology which may later be adapted for use by science coordinators. For example, hazardous waste site construction techniques developed under the hazardous waste program might be given accelerated evaluation and testing in order for them to be available sooner for use in the superfund program. In a similar vein, some of the monitoring systems and quality assurance procedures developed and improved under the hazardous waste research program will be applied and field evaluated under the superfund program.

RESEARCH OBJECTIVES

Since the EPA program offices are the primary clientele of the superfund program, their needs determine the objectives of this ORD program. The EPA superfund program provides emergency cleanup response to hazardous spills and more long-term remedies for releases from uncontrolled hazardous waste sites. Technologies for performing these tasks are relatively new, and their long-term reliability, effectiveness and costs have not been fully evaluated. Hence, this program will assess these technologies and methods. In addition, evaluations will be made of the risks to human health and the environment posed by releases of hazardous materials and by defective, uncontrolled sites.

In addition to cleanup hardware and techniques, instrumentation and analyses, in the form of on-site kits, are needed for screening a variety of samples to determine what samples are suitable for more precise, but more time-consuming and costly, analyses. Physical and mathematical models usable in the field with a minimum of input data are needed for prediction of the movement of released materials. Other efforts will focus on testing and evaluating safety equipment for on-site personnel including communications, protective clothing, breathing apparatus, equipment and standards for personal monitoring for exposure (such as medical monitoring), test systems to assess the human health effect of exposure to hazardous substances, safety procedures for extended site operations, and decontamination procedures for personnel and equipment.

Situation assessment, evaluation of control alternatives, and quality assurance technical assistance during decision-making activities are high on the priority list of support requirements. Also high on the priority list are standard practices for hazardous materials removal and technical support in the review of required program office regulatory support documents.

The program offices have a basic requirement for protocols and procedures manuals for all phases of activity associated with site management. These manuals will cover such problem areas as monitoring methods to determine the extent of contamination in all media, alternative removal or remedial procedures, and technical requirements for post-closure monitoring. Of particular importance are documents establishing generic risk categories as a basis for determining requirements for reportable quantities, sampling, and monitoring.

LEGISLATED RESPONSIBILITIES

Hazardous materials spills have been of concern for decades, and problems with uncontrolled waste sites have periodically caught the public eye. Formal efforts to address these problems were begun a decade ago. At that time the Federal Water Pollution Control Act (FWPCA) (PL92-500 as amended 1978) prohibited unpermitted discharges into waters of the United States and established a fund for responding to discharges of oil and hazardous substances into U.S. waters. The Resource Conservation and Recovery Act of 1976 (RCRA) directed the control of hazardous waste from the time of generation to ultimate disposal. Finally, the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (superfund) provides authority for federal response to the release of hazardous substances into the air, land or water.

The Agency has a lead role in the implementation of each of these Acts. The Office of Emergency and Remedial Response (OERR) was established to implement the superfund legislation. That office shares with ORD responsibility for planning EPA's research and development program in support of Agency superfund activities. ORD's program in this area is in direct support of the superfund roles played by OERR's Emergency Response Division, the Hazardous Response Support Division and the Hazardous Site Control Division, and by the Office of Waste Programs Enforcement, the Office of Solid Waste, the Office of Occupational Health and Safety, and the EPA regional offices.

RESEARCH STRATEGY

In response to the support requirements outlined above as expressed by the relevant program offices, the Office of Research and Development has planned activities in four basic areas: 1) environmental engineering and technology, 2) monitoring systems and quality assurance, 3) environmental processes and effects, and 4) evaluation of adverse health impacts (hazard assessment). Specific activities and projects within these broad categories are described in the following pages.

This strategy covers program office support activities relevant to both emergency response (removal actions) and remedial actions. This division corresponds to the organization of OERR and that of the superfund legislation itself.

Engineering and Technology

Because of fundamental differences in the technology requirements of emergency removal actions and remedial actions, environmental engineering and technology support activities are divided into two corresponding categories.

Removal actions. Removal research activities fall into three major areas: spill prevention and pre-response planning, spill cleanup and safety, and the separation and concentration of hazardous materials. The first area involves the preparation of manuals on prevention and pre-response planning. Technical handbooks are being prepared for use in prevention of hazardous substance spills both inplant and during transportation.

Research in the second area will prepare manuals on emergency spill cleanup, safety, situation assessment, and analytical support. Specialized equipment and procedures for insuring personnel safety above ground and under water will be examined. Guidelines will be produced to aid in the selection of alternative removal methods and in determining the extent of required removal. Also planned are guidance documents on equipment and techniques for control of the spread of contamination. Equipment designed for spill control will be evaluated for cost-effectiveness and multi-media removal capabilities. This equipment includes a mobile incinerator, a carbon-treatment system, a carbon reactivator, and a stream diversion unit.

Research in the third area will concentrate on the separation and concentration of hazardous materials in all media, ultimate disposal of cleanup residuals and restoration of contaminated areas. Technologies for separation and concentration of hazardous chemicals will be advanced through field evaluation. An interim manual on state-of-the-art practices for restoring spill-damaged lands, streams and lakes will be prepared.

Remedial action. Research activities will concentrate on the application of new techniques for pollutant control, adaptation of existing techniques to the special conditions that exist at uncontrolled sites and the evaluation of these techniques for reliability and cost-effectiveness. A survey and assessment of current technologies for remedial action sites will be undertaken to determine what worked under different conditions and what costs and levels of effectiveness can be expected.

Special emphasis will be on the adaptation and demonstration of remedial action technologies and on the analysis of site designs. Remedial technologies and techniques that will have the highest priority for evaluation and adaptation include: methods for ensuring personnel safety, methods which minimize pollutant discharge from sites with a high groundwater table, increasing the *in-situ* stabilization rates of organic contaminants, and the treatment of contaminated soils by chemical and biological modification.

Monitoring and Quality Assurance

Monitoring and quality assurance play an essential role in all stages of site assessment, cleanup and post-closure activities in both remedial and removal actions. Inter-comparison and performance evaluation studies will be conducted to examine the capabilities of analytical laboratories involved in hazardous waste assessment.

A guideline document will be prepared for conducting monitoring assessments at release sites. Emphasis will be on procedures applicable to emergency situations. The document will include information on requirements for: characterizing the waste site location, conducting the emissions inventory, identifying the critical receptor populations, selecting assay and sampling procedures, identifying the major transport pathways and, finally, presenting the requirements for data tabulation.

A manual of methods for the characterization of hazardous waste sites will be published in 1982. The document will present an integrated approach to investigating and studying hazardous waste sites. The manual will be periodically updated to include new and improved sampling methods. The evaluation and field testing of methods will be initiated in 1983.

Special analytical services will be provided to support and maintain the quality assurance and field response requirements of superfund programs. This support will include analyses of quality assurance samples from field investigations, quick turn-around analyses, and analyses of difficult samples with state-of-the-art equipment and methods.

The program will continue to use current and historical aerial imagery in analyzing sites. Site conditions, past and present disposal practices, land-use changes and on-site problems will be depicted. The program will also provide geophysical sensing of buried wastes, monitoring of hydrological characteristics of sites and groundwater, and monitoring of ambient air conditions.

Environmental Processes and Effects

The primary products of this program area are the operational manuals which present information necessary to determine if uncontrolled releases of hazardous substances pose a significant hazard to public health and/or to sensitive environmental areas. Such manuals will, in addition, be of use in determining the extent of contamination and the effectiveness of clean-up actions.

Manuals will synthesize information from recent research into the multimedia transport and fate of hazardous materials. These manuals will enable federal, state and local response personnel to conduct scientific assessments of hazardous waste sites and to select the most appropriate response procedures. One project entails the preparation of a manual synthesizing existing information from recent research on biomonitoring techniques and on the movement, persistence and transformation of hazardous substances through all environmental media. Another project will produce a manual and software packages of the best surface water models for use by the on-scene coordinator in predicting the extent of surface and subsurface water contamination.

Hazard Assessment

As with engineering and technology, health and environmental assessment activities are divided between removal and remedial response requirements. Activities in hazard assessment for emergency response operations focus on rapid turnaround to provide toxicological information on the identified compounds at the site. This information will aid in the determination of the extent of the health risks to the public and will assist the on-scene coordinator in deciding on the best safety measures for protection of workers and the public. Specific activities to be conducted under this program include quick reference works summarizing health hazards for compounds for which subchronic or chronic data exist, and guidelines and methodology for rapid hazard assessment of chemical mixtures based on monitoring data or on historical records.

Activities associated with remedial response requirements include the preparation of hazard profiles and exposure and health hazard assessments for individual chemicals leading to combined, site-specific, health hazards assessments. Research activities include guidelines for assessing health hazards from multi-route exposures to chemical mixtures, and methods for incorporating into the site-ranking process information on toxic effects, no-effect levels, and dependence of toxicity on exposure routes.

MAJOR MILESTONES

Since Superfund is a program of limited duration, research must be done at the beginning of the program if it is to have any impact. Consequently research funding was at its highest level in FY 1982 and will gradually decline from that level. As cleanup manuals and guidelines are completed, funding for those activities will decline.

Among the major specific products planned for this program area are the following:

- Contractor-operated laboratory for analysis of complex samples from removal and remedial programs - 9/1983
- Manual for cleanup site safety equipment and procedures - 10/1983
- Guidelines for use of chemical agents for hazardous materials spills response - 10/1983
- Demonstration of prototype advanced equipment and techniques - 6/1984

RESOURCE OPTIONS

1982 Current Estimate 13.9

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	6.3	6.3	6.3	6.3
MODERATE	6.3		6.5	6.7
HIGH	6.3	6.7	7.1	7.5

Figures are in millions of dollars.

In support of superfund legislation, the immediate effort will focus on development of guidance documents and the technical and scientific back-up for the regions and program offices. Methods will be evaluated for discovering, evaluating, and remedying releases or threats of releases; relative costs of remedies will also be analyzed. Criteria will be developed for determining the appropriate extent of removal, remedy, and other measures and for establishing priorities for actions to deal with releases or disposal sites. Some effort will be devoted to establishing the scientific basis for determining the minimum quantity of hazardous wastes that would trigger a reporting requirement. As superfund is a program of limited duration, research activities are expected to decline in the coming years.

DRINKING WATER

INTRODUCTION

EPA's drinking water research program is designed to support the states and the EPA program office in their implemention of the Safe Drinking Water Act. This research provides support in the areas of contaminant identification and health effects, analytical procedures for monitoring and quality assurance, control technology and costs and protection of underground sources of drinking water. With 49 of the 57 states and territories currently delegated primary enforcement authority for public water systems, this support is increasingly oriented towards local needs. Several groups including the non-governmental National Drinking Water Advisory Committee (NDWAC), the EPA's Science Advisory Board, and the National Academy of Sciences (NAS) have helped to identify the research necessary to answer the following questions: How can analytical measurements be assured to be precise, accurate and thereby create valid data? What unique problems are associated with the delivery of high quality drinking water in small systems? What research should be done and what assistance should be given to the Office of Drinking Water (ODW) relating to drinking water additives? What are the costs of health degradation due to water contamination incidents? How can underground sources of drinking water be adequately protected at minimum cost?

LEGISLATED RESPONSIBILITIES

The drinking water research strategy is guided by P.L. 93-523 and its amendments, which together are referred to as the Safe Drinking Water Act (SDWA). From this and other legislation, EPA is responsible for preserving the quality of drinking water throughout the water cycle and developing programs to set National Drinking Water Regulations. The SDWA requires the Office of Drinking Water to provide National Primary Drinking Water Regulations (NPDWR) in relation to drinking water contamination and human health and to provide National Secondary Drinking Water Regulations concerning human welfare. A memorandum of understanding with the Food and Drug Administration defines EPA's responsibilities in regard to drinking water additives. The ODW provides advice and assistance to states and communities when they encounter extreme or emergency pollution problems for which there are no current guidelines or regulations. The ODW provides health advisories for constituents present in drinking water.

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Section 1442 of the SDWA specifically authorizes EPA to conduct research studies concerning the occurrence and health effects of contaminants in drinking water, analytical procedures for monitoring contaminants, treatment technologies, protection of underground drinking water sources and exploratory research. Health research data helps ODW to evaluate the relative hazards posed by various contaminants and thus carry out the requirements of SDWA Section 1412.

The ODW has set priorities for work areas based on interpretation of the SDWA and its target dates. Shortcomings in existing information and problems referred from the regions, the NDWAC, and the NAS are determining factors as well. The role of the research staff is also important in priority-setting because of the staff's knowledge of time and cost estimates and its experience in designing and conducting research projects.

During 1982, ODW plans to issue several documents related to development of Revised National Primary Drinking Water Regulations. This includes two Advanced Notices of Proposed Rule Making (ANPRM) -- one for organic chemical contaminants of groundwater and one a comprehensive discussion of organic, inorganic, microbial and radionuclide contaminants. In addition, a decision will be made on revised fluoride regulations.

In 1983, ODW plans to continue the development of revised National Primary Drinking Water Regulations which will include publication of Recommended Maximum Contaminant Levels (RMCLs) for organics, inorganics, radionuclides and microbial contaminants, proposed MCLs for volatile organics and fluorides (if appropriate) and a final rule (MCL) for fluoride.

In 1984 and 1985, ODW plans a comprehensive review of all contaminants related to disinfection processes, including trihalomethanes and other by-products, and the disinfectants themselves. ODW's priorities become the basis for the Research Committee's Strategy. Research planned for 1984 and 1985 will in part depend upon the reauthorization of the SDWA and any changes that occur during its reauthorization.

RESEARCH STRATEGY

EPA's basic research strategy is to create a balanced program including short- and long-range health studies, improvements to analytical methods, a quality assurance program and treatment techniques. Many projects consider both ground and surface water problems. In addition, some groundwater protection research has been directed towards understanding and predicting underground movement of injected contaminants.

One area where there is a large need for data is in the measurement of long-range potentially harmful effects of trace organics and the treatment of waters containing them. Another priority area is research into the relationship of inorganic drinking water contaminants (including metals, non-metals, asbestos, radionuclides and corrosion-related issues) to human health. Microbiological contaminant exposure assessment, measurement, effects and control must remain the highest public health priority because outbreaks of waterborne diseases still occur in the United States. Distribution and containment systems in general need more study in order to understand and control corrosion and other situations where indirect additives can be leached into drinking water. Other research efforts seek cost-effective treatment units to remove most of these contaminants from small water supplies that are out of compliance.

Many of the ORD laboratory studies are planned to support ODW in implementing or reducing regulations. In 1982 and 1983, research will emphasize direct support for the regulatory decision processes on volatile organics, microbiological contaminants, radionuclides, inorganic chemicals, and other organic contaminants. A discussion of specific research areas follows.

Exposure and Effects of Contaminants

Advances in methods make it possible to identify and measure contaminants in water which could not be addressed before. Some water treatment technologies and materials presently in use have been found to introduce contaminants into water, or to create in the water reaction products whose existence was not known at the time these treatment methods were developed. Exposure studies provide a basis for surveys or monitoring of the frequency and concentration of contaminants in various types of water supplies and for estimating the amount of a contaminant being absorbed from drinking water by consumers. Exposure studies and pharmacokinetics (absorption, distribution, excretion and metabolism) provide a partial basis for determination of relative source contribution and dose assessment. When adverse effects are known to be associated with a contaminant's occurrence, exposure data may help to focus priorities for control strategies. Health research further determines whether organic, inorganic, radionuclide, microbiological and combined pollutants cause health problems and, if so, how the problem changes with concentration or water treatment method.

Analytical Procedures

A national quality assurance program is mandated to support the SDWA and the National Interim Primary Drinking Water Regulations. This effort includes provision of precise and reliable measurement systems for official use. It includes methods research and methods standardization to provide monitoring procedures for chemicals, radio-chemicals and microbes. Quality control procedures and guidelines are provided for use in documenting data quality and systems performance. The program provides criteria and procedures for on-site evaluation and certification of laboratories, an evaluation of alternate test procedures, and an overview of Agency-wide mandatory quality assurance activities. Some specific functions of the program are: 1) to produce and distribute quality control and performance evaluation samples for chemical and microbiological analysis for water supply laboratory certification programs; 2) to develop and distribute radioactivity standards and reference materials for radiochemistry analysis; 3) to conduct methods validation studies for chemistry, radiochemistry and microbiology; 4) to conduct laboratory evaluations and intercomparison studies; 5) to modify well-sampling equipment; and 6) to conduct feasibility studies for a national program to locate abandoned wells and investigate the feasibility of mapping underground fluid movement from injection wells.

Treatment Technologies

Research is primarily concerned with treatment technologies which will control three types of contaminants: organic chemicals (including disinfection by-products), inorganic chemicals (including particles), and microbiological.

In the organic chemical category, studies are being conducted to increase knowledge of organic chemical behavior in aqueous systems and to assess treatment technologies to determine their feasibility in meeting drinking water standards. Other research covers the removal of organics by aeration and adsorption, control of disinfection by-products, and the role of natural humic substances. Emphasis is on the evaluation of control technology specifically adapted to small systems.

In the inorganic chemical category, there are a number of contaminants of health concern including nitrate, metals and radionuclides. The effects of corrosion in distribution systems on drinking water quality are of major concern. Technology development research focuses on evaluation and field testing of removal techniques for radionuclides and other inorganics including uranium, radium, arsenic, barium, selenium, fluoride, and nitrate, with emphasis on small systems applications.

Research on corrosion control includes methods for protection of asbestos-cement pipe from deterioration, prevention of corrosion of lead pipes by methods other than pH adjustments, control of corrosion in galvanized pipe, and determination of leachates from plastic pipes and various coatings and linings. A corrosion control manual will be produced describing treatment methods and their cost and benefits.

In the microbiological category, technology research addresses the occurrence, identification and control of waterborne pathogens including *Giardia* cysts, *Legionella pneumophila*, and viruses. Studies are included to determine causes of bacteriologic water quality deterioration in treatment processes and in distribution systems. The use of disinfection procedures other than chlorination to reduce organics in drinking water has raised questions regarding the adequacy of microbial control. This problem is being addressed. Research emphasis is on the evaluation of various water treatment processes to remove or inactivate pathogens in small water systems.

Engineering economics is an integral part of the technology research and development. Studies address the development of cost/performance data for water treatment unit processes and costs of treatment technologies for removing specific contaminants. Included is the analysis of the cost-effectiveness of alternatives such as package plants, circuit riders, and regionalization as compliance methods for drinking water contamination in small systems. In addition, efforts are underway to develop improved cost/benefit estimating methods.

Protection of Underground Sources

Research addresses the following four areas: (1) improved methods for detecting contaminants in the subsurface and interpreting the results; (2) methods for predicting the behavior of pollutants in aquifers based on subsurface (site-specific) characteristics and on characteristics of the pollutants; (3) data for regulatory and management decisions on control of specific sources of underground water pollution; and (4) evaluation of water sources for *in situ* aquifer reclamation methods. In addition, several products are being generated to support the Resource Conservation and Recovery Act (RCRA). These products are models and field evaluations to predict pollutant plumes in underground water sources.

The subsurface environment continues to be expensive to access and the results of sampling difficult to interpret in terms of predicting the transport and transformation of contaminants. In 1982 indicators of underground water contamination will be selected and evaluated. The behavior of 20 organic chemicals in a few subsurface environments has already been determined. However, with numerous chemicals of concern and many soil types, the subject has barely been touched. The findings do indicate that we will ultimately be able to determine a few characteristics of concern both for chemical contaminants and soil type which will allow the prediction of the impact of whole classes of chemicals in various subsurface water environments. Also of importance is research into the behavior of microbiological contaminants, especially viruses.

A number of sources of underground water pollution are being studied. Manuals are in preparation on safe injection of treated wastewater and determination of appropriate septic tank density. The latter is being prepared in cooperation with the small wastewater flows research program.

Since the pollution of underground water seriously threatens public drinking water supplies, the underground water sources research program will begin investigating the economic and technological feasibility of cleaning up polluted aquifers in situ. This is generally a very expensive process, but there may be locations where this will either be more cost-effective than treatment, or development of alternate drinking water supplies will be the only feasible option. In 1982 the efficacy of practices tried in the past will be determined.

Exploratory Research

Potential exploratory research subject areas include: adsorption reactions, process improvement, new microbiological quality measurement methods for microbes in water distribution systems, microbial reduction in different treatment trains, modes of viral inactivation, bromide reaction during ozonation, organic compound combustion during granular activated carbon regeneration, industrial recycle/reuse potential, occurrence and health effects of microbial contaminants, and remedial measures for underground water supplies contaminated by agricultural pollutants.

MAJOR MILESTONES

A sample of major milestones in the drinking water research program is listed below.

- State-of-knowledge report on mobility of organic chemicals in different soil regimes - 8/1982
- Report on efficiency of unit processes used in treating drinking water for control of viruses and bacteria - 6/1982
- Description of available methods for determining mechanical integrity of injection wells in terms of accuracy, cost, and effectiveness - 9/1982

- Complete health research for lead, sodium, barium and asbestos - 9/1982
- Determine effects of treatment processes on microorganisms - 8/1983
- Reports on control of organic contaminants from ground and surface sources, control of inorganic contaminants, control of corrosion of distribution systems and removal of particulate contaminants - 9/1983
- Modify well-sampling equipment and report on locating abandoned wells and mapping underground fluids movements - 9/1983
- Report on detection of groundwater pollution by using indicator parameters based on transport and fate - 9/1983
- Report on past groundwater reclamation practices - 9/1983
- Determine the health hazard of Legionella - 10/1984
- Determine effects of chemical contaminants of water including: selenium, selected pesticides, and uranium - 6/1985

RESOURCE OPTIONS

1982 Current Estimate 28.4

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	22.9	22.9	22.9	22.9
MODERATE	22.9	23.6	24.3	25.0
HIGH	22.9	24.3	25.7	27.3

Figures are in millions of dollars.

No growth. Major attention will be placed on developing (1) methods for assessing and monitoring groundwater contamination, (2) methods for determining the adsorption, movement, and transformation of contaminants in the subsurface (especially organic chemicals and viruses), and (3) the scientific data for regulatory decision-making on specific sources of potential groundwater contamination. A new area addressed beginning in FY 82 is aquifer reclamation.

Emphasis will continue to be on determining the health effects of organic, inorganic and microbiological contamination and on developing the methods for controlling contamination in order to support drinking water regulations and health advisories. Emphasis will also be on evaluating technologies which will assist water supply utilities, particularly those serving small populations, in meeting drinking-water regulations.

Moderate growth. Greater emphasis will be given to determining health effects of synthetic organics and methods for organics control.

High growth. Health effects activities will center on conducting toxicology studies on fractionated water samples in order to identify classes of compounds posing the greatest health risks and on assessing the potential extent of those risks. Control technology research will focus on the field evaluation of chemical contamination control systems to establish reliable cost and operating information.

WATER QUALITY

INTRODUCTION

The objective of EPA's water quality research is to provide assessment methods and information that will help federal, state and local governments to make water pollution control decisions that are scientifically defensible, cost-effective, energy-efficient, minimally disruptive to ecosystems and decisions that make optimal use of water resources. The research plan to achieve this objective will, for the next five years, concentrate on support of: future water quality criteria and standards, water quality-based effluent limitations, ocean discharges and disposal, and national strategies for water quality protection and for assessing progress of water pollution control efforts.

LEGISLATED RESPONSIBILITIES

The goal of the Federal Water Pollution Control Act (1948) and its successors, particularly the Clean Water Act of 1977, is improved water quality nationwide. EPA is pursuing the goals of these Acts in two phases. Phase I emphasis is on establishing minimum or base-level point-source pollution control throughout the country. The level of control is determined by state-of-the-art technology and cost. Regulations for these technology-based controls will be largely promulgated in the early 1980s and incorporated into revised effluent discharge permits shortly thereafter. Pollution control facilities constructed in accordance with the new requirements should be completed in the 1980s. Phase II emphasizes development and implementation of a national water quality strategy for cases in which base levels of controls are insufficient or otherwise inappropriate. In keeping with the mandates of the Clean Water Act, the nation's energy and economic problems will be specifically considered in the strategy, as will site-specific water quality objectives.

The water quality research plan is directed toward providing the most important elements of the scientific base needed for effective implementation of Phase II. The most immediate problems are those of a technical assistance nature. In response to the Natural Resource Defense Council consent agreement, for example, EPA is issuing water quality criteria, effluent guidelines, and associated standard reference measurement methods covering 65 toxic pollutants or pollutant classes (expanded to 126 chemicals).

A second task requiring immediate attention is the need to revise ocean disposal regulations developed under the Marine Protection, Research, and Sanctuaries Act for waste residuals and dredged materials. The revisions are necessary to ensure that requirements for evaluating these materials are consistent with the latest state of knowledge and recent court decisions. These revisions will reflect the latest changes in the London Dumping Convention of which the United States is a contracting party. The revisions will also incorporate the requirements on low-level radioactive wastes adopted by the International Atomic Energy Agency. The research effort to support this requirement consists of providing technical assistance in the revision of the regulations in question.

A number of other regulations also are undergoing routine development, revision, and implementation. Some key legislated requirements expected to receive emphasis beginning in 1982 and in forthcoming years are those covering water quality standards, the list of toxic pollutants, designation and determination of hazardous substances, and point source wasteload allocations.

Current priority problems of a longer-term nature are associated primarily with the many deficiencies in the scientific base needed to address toxic pollutants rationally in Phase II. The most significant constraint on effectively addressing Phase II water quality impacts is an inability to accurately quantify the risks associated with long-term exposure to toxins. In Phase I, the basic assumption has been that the benefits of providing the minimum base level of control are worth the costs and need not be specifically demonstrated. Beyond this base level, however, each additional increment of control will come at a much higher unit cost, and the probability of incurring significant economic and social costs in excess of the economic and social benefits becomes greater. Accordingly, a greater effort must be made to target available funds to the resolution of the most pressing problems and the selection and attainment of balanced, reasonable water quality goals.

The proper management of toxic pollutants is of particular concern to state programs responsible for protecting marine and estuarine resources. With increasing amounts of waste being generated, the nation requires the means to dispose of its wastes in an affordable, safe, and aesthetically inoffensive way. Where ocean disposal is a potential alternative, it is essential that adequate information be available to allow environmental officials to make reasoned choices with regard to the use of the oceans for waste disposal.

RESEARCH STRATEGY

To fulfill regulatory mandates for water quality, especially implementation of Phase II as described earlier, research results are needed primarily in the following categories: measurement and quality assurance methods, health and ecological impact assessments, water quality standards derivation, total maximum daily loads, wasteload allocation and impact assessments, cost-benefit analyses for implementing water quality goals, and ocean disposal impact assessments.

EPA's research in these categories provides EPA, state, and local officials with the scientific information and techniques required to identify: 1) existing and potential future water quality problems and their origins, 2) reasonable site-specific water quality goals relevant to key pollutants, 3) current and future levels of pollution control necessary, and the most equitable allocation of allowable waste loadings, 4) the most cost- and energy-effective control strategy for achieving assigned waste loadings, and, 5) the most appropriate institutional mechanisms for implementing the control strategy.

Such a capability requires the availability of the following scientific base:

- A range of cost-effective monitoring and measurement methods for identifying priority waters and evaluating compliance with source-control and ambient quality requirements.
- Field-validated surface water-quality criteria known to closely reflect conditions actually required for various water uses. These criteria should be applicable to identification of impacts of non-point source pollution and deposits of sediment-bound pollutants on aquatic life, recreational, and other uses. The criteria also should permit identification of incremental benefits that would result from additional increments of pollution reduction for a specific body of water.
- Methods for selecting and translating water quality goals into total maximum daily loads and waste load allocations in water-quality limited segments.
- Methods and associated data bases for evaluating environmental, dollar and energy costs and associated benefits of alternative water resource management strategies, including alternative dredge spoil and other waste residual disposal schemes.
- Point source and non-point source control techniques, and water-body restoration techniques whose costs and effectiveness are known for the full range of typical operating conditions.
- Alternative strategies for the effective implementation of water quality management/control systems, alone, and in conjunction with related public or private activities (e.g., flood control or soil conservation).

To be as responsive as possible to immediate EPA needs, efforts will be directed at providing interim techniques and scientific information within one to three years of initiation of each given piece of work. Once this scientific base is assembled, efforts will be directed at testing the validity of and upgrading the earlier products. The research goal here will be to provide the variety of high-quality techniques and data files necessary for effective implementation of a water-quality based program.

To date, Agency reference methods have been completed for the measurement of the Consent Decree toxic and conventional pollutants in wastewater and fresh surface water. However, no low-cost, practical screening techniques exist to scan large numbers of samples for the presence or absence of toxic pollutants in toxic amounts or for sampling or analysis of viruses. Existing reference methods for toxic metals are not sufficiently sensitive. Laboratory-derived water quality criteria for many of these metals are in the order of 0.1 of the minimum concentration detectable by existing methods. Another deficiency is the inability to measure effluent discharge flow at the necessary level of precision to calculate receiving water impacts and, therefore, waste treatment requirements to protect water quality. Lastly, many of the activities providing monitoring data to EPA will require the use of an on-going quality assurance program.

Under the chemical measurement methods sub-program, emphasis will be given to the development and standardization of measurement and quality assurance methods for priority toxic pollutants in fresh and marine bottom sediments, fish tissue, and marine water. A high priority will also be given to increasing the sensitivity of methods for nine toxic metals in water in order to allow measurements at concentrations down to their laboratory-derived criteria values. In the biological methods sub-program, emphasis will be on developing and standardizing methods to quickly and cost-effectively screen for priority wastes with respect to both human health and ecological impacts. Other biological methods research will develop quality assurance procedures for chronic and acute toxicological analysis, standardize microbial/viral sampling and analysis methods, and select techniques for obtaining representative samples.

In the area of physical measurement methods, emphasis will be given to documenting the validity, accuracy, and precision of existing sampling and flow sensing equipment.

Monitoring systems research will emphasize the statistical design of optimal water and sediment sampling programs, as needed in identifying priority waters and determining pollution trends.

Health and ecological effects information is crucial to the water-quality based approach to water-pollution control. Health and ecological criteria based on existing laboratory-derived effects data are almost complete for the 65 consent decree pollutants. Those criteria derived from marginal existing data and those pollutants for which insufficient data existed to develop any criteria require further work, most of which should be completed in 1983. In addition, data on health and ecological effects will be needed in 1983 on 10 to 20 potentially toxic pollutants that are expected to be identified by state and local agencies and EPA abatement and control programs as warranting concern. Just how many of the toxic chemicals will need to be assessed in this manner is not now known. However, the number is not expected to exceed 80 in 1983.

Gaps in data on the health effects of selected pollutants will be filled as required to support or revise criteria. A lower cost, short-term test method will be developed and field tested for use in deriving human health effects data and for screening water samples for the presence of human carcinogens and teratogens. A field validation protocol for translating both health and ecological criteria to site-specific field conditions will be developed for use by the states in setting water quality standards for toxic pollutants. In addition, first generation guidelines will be developed describing the scientific approach to evaluating health and ecological effects of exposure to mixtures of toxic chemicals.

As state and EPA programs continue to review and update state water quality standards, health criteria documents will be reviewed to ensure that up-to-date scientific data are available for state and regional evaluations. The existing criteria are based upon scientific data available in 1980. In addition, a limited amount of effort will be devoted to evaluation of local health hazards prior to finalizing state standards and permits. Outputs would include health assessment or mini-criteria documents.

A small effort will be undertaken to field-evaluate selected laboratory-derived ecological water-quality criteria and to identify field situations in which criteria adaptation protocols are most urgently needed.

Development efforts will continue on protocols for translating laboratory-derived freshwater and marine ecological criteria to site-specific field situations. This work is expected to require five years or more to complete, with useful outputs produced serially as work progresses.

Work on assessment procedures for determining biological integrity of fresh waters and for distinguishing natural vs. human influencing factors will be continued. These procedures are needed for identifying stream reaches where meeting specified quality standards will not improve the fisheries or allow other additional beneficial uses, and for evaluating where goals of the Clean Water Act are and are not being met. These same procedures also are useful in identifying priority waters in terms of adverse ecological impacts, and for distinguishing between the adverse ecological impacts resulting from POTW discharges and storm-sewer discharges in urban areas.

Some of the available mathematical models for identifying water-quality limited stream segments and making wasteload allocations of conventional pollutants have not been adequately field validated. Existing models are inadequate for making wasteload allocations of the priority toxic pollutants. They will be expanded to address toxic pollutants both in the water column and in sediments and to predict environmental exposures resulting from alternative levels of toxics control. Selected waste-load allocation models will be upgraded to provide a capability to address toxic metals. The objective is to provide a capability to determine discharge limits necessary for each permittee in order to comply with water quality standards.

Work begun in 1981 on a generic protocol for toxicity wasteload allocations, based on effluent bioassays, will continue. This protocol, if successful, will allow wasteload allocations to be based on the net (i.e., resultant) toxicity of all the various toxicants present in discharges in combination, thus avoiding the more costly and time-consuming chemical-by-chemical approach to wasteload allocations.

Work on development of the toxic metals exposure analysis modeling system (MEXAMS) will continue. Operation of the Center for Water Quality Modeling will continue to provide manuals and computer tapes/card decks on various models to states and EPA client offices and to assist them in their use.

A technique has been developed for predicting the movement and dispersion of effluent plumes in marine waters. Interim techniques have been developed (but not fully field validated) for estimating the ecological impact of dredged material disposal in ocean waters. In addition, techniques for measuring pollutant effects on marine organisms in the laboratory have been developed. Work on ocean disposal impact assessment will focus on continuing the development of techniques applicable to both shore-based point source discharges and ocean disposal of waste materials. The techniques are for: predicting the ecological impacts of proposed discharge/dumping options, identifying acceptable discharge/dumping options, and documenting the ecological impacts of current discharge/dumping practices. Technical analytical support also will be provided in the review of applications for POTW modifications under Sec. 301(h) of the Clean Water Act.

MAJOR MILESTONES

There is a multitude of regulatory development and enforcement support services provided by the water quality research program. These include review of health-based water quality criteria, provision of health assessments, development of sediment and dredge spoil impact assessment protocols, quality control support, and review of requests for modifications in waste treatment requirements.

In addition, major research output milestones include the following:

- Guidelines for using criteria in complex mixture exposure situations - 6/1983
- Monitoring guidelines for rapid biological screening techniques to characterize water quality problems - 8/1983
- Model for making toxic metals wasteload allocations among dischargers - 9/1983
- Field evaluate and validate water-quality criteria development protocols for freshwater and marine applications - 9/1983
- Procedures for determining biological integrity of fresh waters and distinguishing natural from human influences - 12/1983
- Standard chemical speciation monitoring systems - 8/1984
- Statistical sampling programs to measure local water quality trends in both water and sediments - 8/1984
- First generation toxic metal exposure analysis model - 12/1984
- Develop and field test short-term tests for health endpoints in priority waters investigations - 1984
- Procedures for predicting ecological impacts of, and criteria for establishing 'unreasonable degradation' for, ocean dumping - 3/1985

- Standard technique for detecting trace levels of contamination of fish tissue - 6/1985
- Protocols for determining transport, fate and probable ecological effects of ocean outfalls - 4/1986

RESOURCE OPTIONS

1982 Current Estimate 19.1

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	11.0	11.0	11.0	11.0
MODERATE	11.0	11.4	11.8	12.1
HIGH	11.0	11.8	12.5	13.2

Figures are in millions of dollars.

No growth. Emphasis will be on the development of interim measurement methods, of the capability to derive site-specific water quality standards. Priority will also be given to developing alternative abatement strategy impact assessment techniques needed in pursuing a water-quality based approach to the control of toxic pollutants. Criteria document support for the regulatory offices will continue.

Moderate growth. Some work on the most essential research areas addressed in the No Growth option will be accelerated.

High growth. Work on the essential research areas addressed in the above options would be further accelerated.

INDUSTRIAL WASTEWATER

INTRODUCTION

The aims of EPA's research and development efforts in the area of industrial wastewater are twofold. First, they are to establish a sound technical and scientific basis for regulations and policies. Second, they are to identify lower cost and more efficient methods for mitigating water pollution resulting from industrial discharges. Specific activities range from the development of techniques to simplify the issuance of industrial discharge permits to the pursuit of fundamental scientific knowledge upon which to develop environmental policy decisions related to control of industrial pollution.

The pollution problems included in the industrial wastewater area covers the wastewater discharge problems of the manufacturing and process industries. The research covers the development of technically and economically feasible methods for pollutant measurement and monitoring and for pollution control of industrial effluents. ORD's efforts also provide direct analytical, quality assurance and other technical support for establishment and revision of effluent guidelines and issuance of discharge permits.

The principal client program offices within EPA are the Office of Water Regulations and Standards and the Office of Water Enforcement of the Office of Water. These offices, along with EPA's regional offices and the states, are charged with establishing effluent guidelines, issuing individual industrial discharge permits, and enforcing compliance.

Perhaps the major "issue" in this area regards the balance between technology-based and water quality-based philosophies for the promulgation of industrial effluent guidelines and the issuance of discharge permits. In this context, the Agency will continue to require its research program to collect and analyze technological, economic, health and general environmental factors for the finalization of specific regulations required by the Clean Water Act. More and better information of all types will be necessary for the conduct of meaningful risk-benefit analyses.

A second issue of continuing concern is simply the nation's cost burden in complying with discharge and pretreatment regulations. The cost burden with regard to both industry's cost in achieving compliance and regulatory agencies' costs in permitting and compliance monitoring must be minimized to the greatest extent possible.

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LEGISLATED RESPONSIBILITIES

A number of provisions of the Clean Water Act (P.L. 95-217), in addition to Title I, Research and Related Programs, which directly authorizes a range of research and development activities, reflect the need for new technical or scientific information. One of these provisions, the National Pollutant Discharge Elimination System (Section 402), serves as the basic regulatory tool for the control of industrial water pollution. Under this provision, EPA or approved state regulatory agencies issue permits limiting the release of various pollutants. Technologically attainable discharge limits must be identified by EPA through promulgation of effluent guidelines for particular industries (Section 301). The initial set of guidelines and permits supported the achievement of best practicable technology (BPT), aimed at the earliest possible control of conventional pollutants. A 1976 consent decree plus the 1977 amendments to the Clean Water Act modified the Agency approach by identifying 65 pollutant classes on which the Agency would be required to focus regulatory efforts. These "priority pollutants," plus others as appropriate, are to be considered by EPA in the preparation of further effluent guidelines which define best available technology economically achievable (BAT).

BPT, best conventional pollutant control technology or BCT, BAT and associated permits are characterized as "technology-based." In other words, they call for discharge limits based on what current treatment technology can achieve -- limits independent of the receiving water to which the wastewater is discharged. They require research information on the treatability of various pollutants by various types of treatment processes along with information on the costs of treatment, its reliability, conditions under which it can be used, etc. Where additional treatment beyond BAT is required to protect receiving water quality, as in areas with large numbers of dischargers and/or relatively small stream flows, case-by-case decisions are made by the permitting authority such that adequate water quality will be achieved in the receiving stream (Section 303). These "water quality-based" actions require research information such as how to enhance existing treatment process performance, what innovative treatment and control options are practicable and what the costs would be for various levels of control.

In addition to the above requirements for direct dischargers, pretreatment standards, which describe comparable treatment needs for industrial discharges into municipal treatment facilities, were also required by Congress (Section 307). The legislative mandate for technology-based standards, pretreatment standards, and water quality-based permits require a variety of research results.

In developing new regulations and in reviewing existing ones, there is a major effort to integrate requirements of the Clean Water Act with those of other statutes. As an example, new technology for recycle and reuse of industrial wastewater and its constituents is being considered both in the development and review of BAT regulations and in related Resource Conservation and Recovery Act (RCRA) requirements for disposing of hazardous industrial wastes.

The 1976 consent decree and the recent Clean Water Act Amendments have added new requirements to the regulation of industrial wastewaters. Supporting research, in addition to establishing the removal capabilities and costs of various treatment options and developing new and improved control technologies, also needs to develop reliable, practicable and cost-effective analytical techniques and monitoring methods for many individual toxic pollutants.

With the Office of Water Regulations and Standards (OWRS) now moving into the final phase of its schedule to promulgate BAT guidelines for the most important industrial categories, a higher ratio of short-term technical support to longer-term research by EPA's research program is seen as desirable by that Office. The Agency's regulations for BAT, new source performance standards and pretreatment standards are now aimed at controlling the wastewater discharges of the "priority pollutants" -- some 126 specific toxic chemicals from a number of primary industry categories. Many studies have been or are nearly completed and proposed regulations are being issued.

For the Office of Water Enforcement (OWE) and the regional offices, it seems clear that increasing reliance on individual permitting decisions at the regional office and state level is desirable. This, in turn, places priority for support from ORD on information for the issuance of individual permits and methods for expediting the permitting process.

RESEARCH STRATEGY

Industrial wastewater research efforts will be aimed primarily at providing more cost-effective measurement and control methods for toxic pollutants, particularly those listed in response to CWA Section 307 (the priority pollutants), to enable industry to comply with EPA regulations. The thrust toward more cost-effective alternatives is aimed at meeting industry's needs for satisfying permit requirements and reflects a shift in emphasis, now underway for more than a year, toward facilitating permit issuance by EPA and the states and permit compliance by industry and away from support of effluent guidelines development as Agency effort on Best Available Technology (BAT) winds down. "Consulting-type" responses and technical support to the client offices will still be provided for high priority needs.

Over the next five-year period, the balance of effort will move from short-term client office technical support toward longer-range, more fundamental research.

Planned efforts will improve measurement and control capabilities for the legally-defined set of CWA Section 307 toxic pollutants and will broaden the identification of toxic pollutants in industrial wastewaters. In addition, EPA's research will provide monitoring and control methods for those industries that are most important from the standpoint of impacts on human health and on the environment. The importance of conventional pollutants will be periodically re-evaluated, however, to assure that research and development continues to focus on the most important problems as well as to determine if more conventional and easier-to-measure parameters can serve as appropriate and less costly replacements for detailed and relatively expensive pollutant-by-pollutant assays. The search for less costly parameters is prompted by the complexity and cost of determining the individual concentrations of numerous toxic compounds. In addition to the more traditional analyses, other possible alternative parameters include use of a pollutant class characteristic, e.g., a structural property or the measurement of an overall waste characteristic such as "toxicity to living organisms." These parameters could be useful as compliance parameters and in monitoring of effluents as well as in evaluating the effectiveness of various treatment and control options.

The general R&D approach is traditional-problem definition, assessment of already-available solutions, identification of research objectives and then desk-top analysis, bench-scale experiments and pilot-scale development efforts followed by full-scale prototype demonstration where appropriate. When investigating control alternatives, generic approaches applicable across several industries will be pursued when possible rather than taking an industry-by-industry approach. Moreover, this strategy recognizes that, increasingly, non-conventional approaches should be examined. This includes consideration of improved and up-graded end-of-pipe treatment methods (end-of-pipe control will continue as the mainstay for industrial pollution control for some time to come) including examination of the reductions in industrial pollution discharges which could be attained through low-cost concepts such as improvements in treatment plant operation and maintenance or even in plant management practices or "housekeeping." Also included are wastewater recycle/reuse and process change/raw material change concepts. It must be stressed, however, that while recycle/reuse and process change and best management practices will be important components of least-cost industrial pollution control solutions in the future, the private sector is being relied upon to take the primary initiative in these areas.

R&D resources will generally be allocated to those industry categories with known or potentially high human-health or ecological impacts. Efforts will be concentrated on those industries that discharge waste streams with components that are suspected of producing serious or irreversible human health or ecological impacts. A major research challenge will be to assess the significance and the treatability of the many chemical compounds which have been and are being identified in various industrial effluents and which are not now included in the present priority pollutant list. In addition, identifying industries whose environmental impacts are particularly widespread, either through manufacturing locations or product-use patterns, provides another criterion for focussing industrial wastewater research. Because of possible new types of environmental problems which might result, special attention should also be given to the potential water pollution problems of newly-developing industries such as solvent or oil recovery, genetic engineering and hazardous waste disposal.

The Agency's recent initiative toward consolidated permitting procedures, together with the need for cost reduction in regulatory compliance, has focused attention on cross-media implications of wastewater control options. That is, serious consideration must be given to assuring full cognizance of the air and land pollution consequences of various water pollution control alternatives -- and vice-versa, viz., the water pollution implications of new and different kinds of air and land pollution controls must be recognized and evaluated. This is particularly important with regard to hazardous waste generation as a result of increased waste treatment efficiencies.

Finally, it is recognized that cooperation between ORD and industry will be beneficial. A maximum rate is attained when enforcement and regulatory efforts are complemented by cooperative liaison with industry. Such liaison 1) promotes realistic appreciation by EPA of the technical and economic factors which impact industry's ability to comply with regulatory and enforcement actions and 2) promotes reasonably substantial progress by industry in developing and putting into practice new, more effective and more economical technological solutions to industrial waste problems.

In meeting specific commitments and carrying out continuing support activities, emphasis will be given to the following areas: ensuring data quality, least-cost control options, treatability studies, characterizing and monitoring complex effluents, early-warning studies and technical assistance.

Ensuring Data Quality

Many important policy and funding decisions at local, state and federal levels and in private industry rely on data obtained from sampling and analyzing pollutants in industrial wastewaters. It is essential that such data be reliable and accurate. This can be assured only through the vigorous application of quality assurance techniques such as verifying the efficacy of the analytical methods used, auditing the performance of analytical laboratories and even conducting performance evaluations of individual analysts. If carried out on a continuing basis, these actions will assure that results obtained are of consistently good quality.

Many analytical methods currently in use remain incompletely tested. Also, new analytical methods are constantly emerging and are only tenuously applicable to EPA and state regulatory needs because they may be unreliable and lack verification. Even when an analytical test procedure has been thoroughly tested and its performance expectations are known with a high degree of confidence, factors of which the analyst is not aware can render the test unreliable. Data generated can be completely false. For these reasons, tools and laboratory protocols are provided by this research program for quality control and quality assurance. Quality control protocols provide check systems whereby analysts can evaluate their own performance.

Quality assurance protocols are quite adequate for BOD, COD, nutrients, minerals and trace metals. However, for trace organic priority pollutant analyses in complex industrial discharges, especially for organic chemical pollutants from the synthetic organic chemicals manufacturing industry, the protocols are less reliable.

A primary focus of this work involves the provision of certified monitoring methods and quality assurance support for chemical, physical and biological analyses and bioassays for EPA's overall regulatory and enforcement programs. The monitoring and quality assurance research efforts also offer direct, ongoing technical support to EPA's effluent guidelines and water permitting programs. This includes assistance in the performance evaluation of NPDES discharger laboratories and the evaluation of the quality of the data which are generated and submitted in discharge monitoring reports. This is part of an Administrator-mandated Agency-wide quality assurance effort related to monitoring data. Continuing support is provided to the Office of Water Regulations and Standards, the Office of Water Enforcement and the regional offices.

Least-Cost Control Options

It is important that necessary pollution control requirements be achieved by industry at least possible cost. Additional research priority will be given to possible improvements in operation and maintenance of existing industrial waste treatment facilities which can yield enhanced performance at little or no additional capital cost. In this respect, full-scale evaluations of both conventional and improved biological treatment systems are carried out. These studies should provide definitive information on which the Agency can base decisions regarding the use of biological treatment alone in meeting effluent limitations for the priority pollutants. In addition, as new or newly-recognized industrial pollution problems arise, cost-effective source controls may be needed.

Treatability Studies

The treatment of industrial pollutants is based on their susceptibility to removal, destruction, or detoxification by various physical, chemical, or biological processes. Having ready access to information on how different pollutants respond to various treatment alternatives is important in preparing effluent limitation and pretreatment regulations and in issuing discharge permits. Data on the treatability (removability) of priority pollutants have been compiled and formatted into a Treatability Manual for joint use by permit writers (state or EPA personnel) and by industrial permit applicants in expediting and simplifying negotiation of realistic and attainable permit conditions. Further effort is planned to assure both currency and reliability of data and to extend usefulness accross a wide range of U.S. industry categories, especially the organic chemicals manufacturing industry. An up-dated manual has been produced and a computerized design and a cost model for industrial wastewater treatment is to be incorporated in 1983. Research efforts involve obtaining, analyzing, and compiling data on pollutant treatability, with specific emphasis on toxic pollutants. Data on the treatability of "toxicity" by various control technologies is also being compiled. Treatability studies range from experimental evaluations of specific pollutant removals by various processes to the development of theoretically-based predictive models of pollutant treatability.

Characterizing Complex Effluents

Since many industrial wastewaters contain mixtures of 10 to 100 or more individual toxic compounds in varying concentrations, the cost to monitor each compound individually and to characterize the effectiveness of various treatment processes would be high. One alternative approach is to develop bioassay techniques capable of directly measuring "toxicity" (i.e., the combined toxic impact of all toxicants present in the wastewater). Such methods would not only greatly reduce the cost of analysis but would help move more quickly to a more realistic understanding of the actual water quality impacts of industrial wastewaters on rivers and streams. Currently available aquatic bioassay methods are limited in applicability and most methods can assess only acute, short-term toxicity to fish and aquatic life. More reliable and more widely applicable methods will be investigated, particularly methods which ultimately would allow us to relate industrial wastewater quality to human health implications in downstream public water supplies. The success or failure of work in this area will influence where future emphasis in both monitoring and control technology research should be placed.

Early-Warning Studies

Rather than spreading research, regulatory and industrial pollution control resources broadly across all categories of industry, all areas of the nation and all types of pollutants, research information is needed to help focus limited environmental protection resources on those problems of greatest concern and on prevention of new problems before they emerge. In this regard, effluents from the 21 industrial categories covered by the Consent Decree have been characterized primarily with respect to the list of specific priority pollutants. Work is underway to identify other potentially toxic organic chemicals found repeatedly in effluents typical of each of the industrial categories. This information is needed to determine which toxic pollutants warrant closer attention and to evaluate the reliability and usefulness of the above-mentioned bioassay techniques for toxicity determinations. The characterizations need to be sufficient to provide inputs to mathematical models that predict fate and transport for use in risk assessments.

Technical Assistance

Second Round NPDES permits will require complex technical and economic issues to be addressed. Biological assessments, engineering analyses and statistical evaluations, for example, will be required for many of the major industrial permits. ORD's expertise in specific areas, particularly the chemicals and related industries will be provided on an as-required basis. Technical assistance will include participation on industry teams, special engineering analyses and toxicity reduction plans, for example.

MAJOR MILESTONES

Much of the ORD support for the Agency's efforts on regulating industrial wastewater discharges is of a continuing nature. The provision of quality assurance (QA) for sampling and analysis activities by EPA, the states and by industry itself is a good example. Similarly the validation and standardization of new analytical methods for non-priority-pollutant pesticides, etc. and the correction of deficiencies in such methods must, of necessity, be of an on-going nature.

Specific milestones expected include:

- Publication of up-dated Treatability Manual - 7/1982
- Report on high surface area electrochemical waste treatment technology - 9/1982
- Promulgation of the analytical methods regulation for the priority pollutants - 7/1982
- Incorporation of design and cost model for industrial wastewater treatment into Treatability Manual - 2/1983
- Identification of priority and other pollutants in industrial wastewaters by spectral matching of GC/MS tapes - 10/1983
- Report on use of operation and maintenance techniques to improve the cost-effectiveness of already-installed treatment facilities - 9/1984
- Report on lower-cost treatment technologies - 10/1984
- Report on viability of toxicity reduction concept as an integrated compliance parameter for complex industrial discharges - 6/1985

RESOURCE OPTIONS

1982 Current Estimate 9.4

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	5.0	5.0	5.0	5.0
MODERATE	5.0		5.2	5.3
HIGH	5.0	5.3	5.6	6.0

Figures are in millions of dollars.

No growth. Future efforts will emphasize provision of essential support to permitting and compliance monitoring efforts by EPA and the states. Analytical methods will be standardized and validated and, where necessary, shortcomings in methods will be corrected. Quality assurance support to Agency, state and discharger laboratories will be provided. In further support of permitting, additional pollutant treatability and toxicity reduction data will be generated from pilot-scale studies on wastewaters containing highly toxic components. Related cost vs. performance correlations will be developed to support cost-benefit evaluations associated with use-attainability determinations.

Moderate growth. In addition to the above efforts, work will be conducted to develop the toxicity reduction concept as a means of simplifying permit issuance and compliance monitoring.

High growth. In addition to the above efforts, attempts to develop lower-cost analytical surrogates will be made.

MUNICIPAL WASTEWATER

INTRODUCTION

More than 15,000 publicly owned treatment works (POTWs) exist in the United States. These facilities treat the liquid waste of a population of more than 156 million people and the wastes from thousands of industrial and commercial facilities. This results in a total flow of more than 34 billion gallons of treated wastewater each day. By the year 2000 more than 21,000 POTWs are expected to exist and to serve more than 250 million people. In addition, more than 12 million people are currently served by on-site treatment facilities -- primarily septic tanks.

The impact of the discharge of such large volumes of municipal and industrial wastewaters to this country's waterways and land surfaces can be severe unless adequate treatment and management practices are used. Bacteria and viruses in wastewater can cause cholera, hepatitis, and amoebic dysentery. Oxygen-using organic material can deplete lakes and streams of oxygen necessary for the survival of fish. Municipal wastewater also contains materials (phosphorus and nitrogen) that stimulate the growth of algae. An excessive algal growth can produce thick mats that interfere with recreation, cause unpleasant taste and odors in water supplies, and exert a significant oxygen demand after the algae die. Toxic materials in municipal wastewater can kill fish and deteriorate sources of drinking water.

LEGISLATED RESPONSIBILITIES

The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500), as amended by the Clean Water Act (CWA) of 1977 (PL 95-217) and the Municipal Wastewater Treatment Construction Grant Amendments of 1981 (PL 97-117), form the legislative basis for the Agency's efforts in municipal wastewater pollution control. Basic to the Act is the imposition of technology-based controls on municipal wastewater discharges. Section 104(d) of the CWA requires that EPA develop and demonstrate practicable means of treating municipal sewage to support the multibillion dollar Construction Grants program. This provides the fundamental impetus to EPA's research efforts in control technology development. The specific requirements of the Act foster research activities in several areas:

Toxic pollutants control. Section 307 of the CWA allows credit for the removal of toxic pollutants by publicly owned treatment works in the setting of pretreatment standards for industrial dischargers to POTWs. Research on removal of toxics by POTWs is helpful in establishing a basis for determining removal credits.

Sludge management. Section 405 of the CWA requires that EPA issue guidelines for the disposal and use of wastewater sludge. Additional legislation under the Resource Conservation and Recovery Act (RCRA) of 1976 (PL-580) defines sludges from wastewater treatment plants as solid waste, and requires that solid wastes be used or disposed of in a safe and environmentally acceptable manner. EPA also carries out research to develop alternatives to ocean dumping as a sludge disposal option.

Land treatment/aquaculture. Section 201(g)(5) of the CWA prohibits the award of a construction grant unless land treatment has been fully studied and evaluated. In addition, Section 201(d) encourages recycling of potential sewage pollutants through agriculture, silviculture, or aquaculture techniques.

Small wastewater flows. Section 104(q)(1) of the CWA requires EPA to conduct a comprehensive program of research and investigation into preventing, reducing or otherwise eliminating pollution from sewage in rural and other areas where collection of sewage in conventional, community-wide collection systems is impractical or where soil conditions or other factors preclude the use of septic tank and drainage field systems. In addition, Section 104(q)(3) requires the establishment of a national clearinghouse for receiving and disseminating information concerning small wastewater flows, and Section 205(h) requires 4 percent of the construction funds to rural states (34) to be set aside for small rural communities.

Innovative and alternative (I/A) technology. Section 201(g)(5) of the CWA requires the detailed consideration of I/A technologies as part of each Construction Grant application. The Act authorizes a federal share of up to 85 percent for eligible construction costs for I/A projects and the option to select I/A technologies that are up to 15 percent more costly than conventional practices. It further provides for 100 percent grants to replace or modify I/A technology failures and specific set-asides in the state construction grant allotments devoted to funding I/A projects.

Health effects. Since many of the provisions of the CWA are predicated on the need to protect public health, ORD's health effects research supports requirements of the CWA for the safe treatment, disposal and/or reuse of municipal wastewater and sludge, and for the development of a health effects data base for setting water quality standards and effluent guidelines.

Municipal Construction Grant Amendments of 1981

The Municipal Construction Grant Amendments of 1981 authorize EPA to grant to states up to $2.4-billion per year during fiscal years 1982 to 1985. In addition, $200-million is authorized for grants to correct combined sewer overflows. The federal share for construction of conventional treatment works will be reduced from

75 to 55 percent beginning in FY 1985. The only projects exempt from this reduction in funding are segments of treatment works where the initial segment received funding prior to October 1, 1984. The new amendments also encourage states to assume greater management of the Construction Grants program. Another major provision of these amendments is that, effective October 1, 1984, construction grants will be primarily for construction of treatment plants, innovative/alternative projects, infiltration/inflow projects, and interceptor sewers. A state may only spend up to 20 percent of its federal share on collector sewers and other ineligible projects. In addition, beginning on October 1, 1984, grants can be made for combined sewer overflow projects in priority water quality areas.

RESEARCH STRATEGY

In concert with the new policies of the construction grants program, the municipal wastewater research program will focus its future activities on supporting the states in carrying out their water pollution control programs. Emphasis will be on the development of efficient and cost-effective treatment technologies to assure that municipalities have the tools necessary to carry out their environmental programs effectively and economically.

The EPA research program will: (1) augment technology transfer activities to provide technical assistance to states and municipalities in solving local problems with state-of-the-art control technologies, (2) accelerate and encourage the use of innovative and alternative technologies by providing technical support, technology transfer and assessments of emerging technologies to states, municipalities and design engineers, (3) develop improved process design data and provide information that reduces construction and operating costs while improving performance, reliability and/or efficiency of publicly owned treatment works, and (4) provide health effects data and assessments associated with various treatment technologies.

The municipal wastewater research program currently focuses on the following areas: innovative and alternative technology, plant operation and design, sludge management, new treatment process development, land application of wastewater, small wastewater flows, toxic pollutants control, urban runoff, and health effects.

The innovative and alternative program will provide technical support to encourage the use of I/A technologies by municipalities. EPA's I/A technology research program is actively evaluating new technologies that enhance the ability of municipalities to meet discharge limitations in a cost-effective manner. The emphasis is on assessing emerging technologies that may help to reduce capital, operational/maintenance, and/or energy costs. Several assessments of emerging technologies will be published to promote their use by the regions, states, municipalities and private sector. An information clearinghouse will be operated in support of the states and municipalities.

There is a continuing need for methods to upgrade plant design and improve plant operation. EPA's research will focus on: (1) identification of any operational, maintenance, and design problems that affect POTW compliance capability, (2) preparation of documents for use by treatment plant designers on the effects of peak flows, aeration devices, energy conservation, and sidestreams, (3) investigation of unit process reliability for future design considerations, and (4) improvement of process control reliability through development of better application information and the establishment of a self-supporting Instrument Testing and Certification Institute.

The sludge management research program continues to hold a high priority. Sludge management represents a major operating cost and environmental problem for municipalities. Research will focus on providing more efficient and low-cost processes for the treatment, conversion, use and disposal of sludge from publicly owned treatment works. Major emphasis will be on: acceleration of the development of the two-phase anaerobic sludge digestion process which has the potential of reducing capital costs and increasing the gas yield, evaluation of in-vessel composting and sludge to fuels, and the application of cellulose enzymes for increasing destruction of sludge. Efforts in sludge dewatering, incineration and assessment of the effects of heavy metals from land application to food-chain crops will be reduced.

Conventional biological treatment plants can be expensive to operate due to high capital, space, manpower and energy requirements. EPA's research into new process development aims to enhance the ability of municipalities to meet discharge limitations with the least-cost combination of processes. Oxygen-demanding solids, harmful microbes and specific pollutants, such as the priority pollutants and the nutrients phosphorus and nitrogen, are primary concerns in this research. Current emphasis is on evaluating novel biological concepts and processes which may reduce cost and energy requirements, increase reliability, reduce solids production, lessen intermedia impacts and conserve natural resources. Efforts in specific pollutants and wastewater disinfection will be reduced.

In many areas of the nation, land treatment can be a particularly effective procedure for treating wastewater while at the same time reducing costs and/or using the wastes as nutrients and the water to irrigate cover crops. With this in mind, research will be devoted to developing design and operating information for rapid infiltration and overland flow systems. The effects of colder climates on overland flow systems, the more efficient management of vegetative cover, the management of nitrogen particularly in rapid infiltration systems, and the ability of these systems to treat complex organics will be examined. Research will also address aquaculture. Here, EPA research will produce design and operating information for using water hyacinths and other plants for wastewater treatment. A newly developed high-rate aquaculture process called the nutrient film technique will be evaluated on a small scale at a municipality.

The Clean Water Act requires that rural states set aside four percent of their Construction Grant allotment for small communities. The shortfall of technology applicable to small communities and onsite use must be alleviated if system failures are to be avoided and costs controlled. The current research program is directed toward development and dissemination of a range of technologies in the form of handbooks for design, operation and management. Specific activities include: the Small Wastewater Flows Clearinghouse that provides ready access to technical information by the user community, the Cincinnati center for the controlled study of viable alternative technologies, development of a handbook on alternative wastewater collection systems for use by private design engineers, and regional and state program managers in providing technical assistance.

The toxic pollutants control program research will produce information on the sources and treatability of toxic pollutants as well as develop strategies for toxics control. The major focus of this program is on: a report which characterizes the sources, occurrence, and concentration of the influents and effluents in POTW systems, reports on the treatability and removability of priority pollutants and other toxic organics by a variety of conventional and advanced processes and toxic control options and strategies using various modeling and systems analysis approaches. The results of this research will aid in determining the levels of toxic industrial waste discharge a POTW can handle without adverse effect on its treatment process. Currently, wastewater characterization work is being completed, and the program will focus its in-house resources on treatability studies.

Historically, the urban runoff program has provided the research support for the Construction Grants, Great Lakes, and Nationwide Urban Runoff Programs. This support includes conduct of problem assessments, development of cost-effective control technologies, evaluations of best management practices, and the development and documentation of management tools. The program is being phased down considerably in 1982, with the development of new infiltration/inflow measurement and control techniques receiving continued support.

The municipal wastewater health program focuses on three primary areas: land treatment of wastewater, wastewater aquaculture, and land application of sludge.

In the land treatment area, epidemiological studies of human infectious disease will continue at land treatment sites in Texas and Israel. Research is progressing on determining the fate of intestinal pathogens during pre-application treatment, particularly in wastewater stabilization ponds (holding ponds, lagoons). This research will be expanded to include the study of the soil matrix under various environmental conditions. Research will also determine the consequent entry of bacterial and viral pathogens into groundwater and the food chain. Since the health response of any particular dose of virus depends upon the minimum infective dose, research in this area has high relevance.

EPA research will evaluate the use of pretreated wastewater in commercial aquaculture. Products from such aquaculture systems will be evaluated for the presence of harmful toxic organics, trace elements, and human pathogens. This research is important in determining the potential health problems from human consumption of food products (fish and shrimp) grown in wastewater aquaculture systems.

Land application of sludge to food-chain crops has the potential of causing disease in humans from either microbial pathogens or toxic pollutants by exposure through direct contact, bioaccumulation in food products, or groundwater contamination. Research will determine the public health hazard of exposure to microbial pathogens as a result of land application of sludge. In addition, the bioaccumulation of toxic organics and heavy metals in plants and animals grown on sludge-amended soil will be more precisely defined. To date, animals fed crops grown on sludge-amended soil have shown increased metal concentrations in certain organs as well as evidence of reproductive effects. When available, the results of this research will be used in developing guidelines for safe sludge disposal.

MAJOR MILESTONES

Emphasis will be placed on early identification and examination of critical operating parameters for emerging and alternative technologies before characteristic O&M problems develop. Improved guidance and design information will be disseminated for both conventional and newer technologies. In the innovative and alternative technologies research program, technical assessments of recent technology developments will provide an in-depth process description, an analysis of technical risk of implementation, an evaluation of performance costs, operation and maintenance requirements, energy utilization, and design considerations, a comparison with equivalent conventional technologies and an assessment of potential national impact.

Specific milestones expected include:

- Production of emerging technology assessment reports by the innovative and alternative technologies research program - 2/1982 to 9/1984
- Design information series to supplement existing body of information on design of POTWs - 5/1982 to 9/1986
- Completion of health assessments for land application of municipal wastewater (subject to periodic updates) - 1/1983
- Preparation of summary document on health effects of cadmium in humans to support regulations to be developed for sludge disposal under RCRA and the Clean Water Act - 12/1984

RESOURCE OPTIONS

1982 Current Estimate 16.6

GROWTH	1983 Projected	1984 Projected	1985 Projected	1986 Projected
NO	11.6	11.6	11.6	11.6
MODERATE	11.6	11.9	12.3	12.7
HIGH	11.6	12.3	13.0	13.8

Figures are in millions of dollars.

No growth. Major emphasis will be on research to develop and evaluate innovative and alternative control technologies. Particular emphasis will be on developing more effective sludge management alternatives and improving the operation and maintenance of treatment plants and their energy efficiencies.

Moderate growth. Further advances will be pursued in the development and demonstration of technologies for aquaculture.

High growth. Major emphasis will focus on providing expert technical support and development of new or improved on-site wastewater management systems.